REPORT

SOURCE AREA CHARACTERIZATION - UBZ-2

Monsanto Soda Springs Idaho Plant

Submitted To: Monsanto Soda Springs Plant
Highway 34
Soda Springs, ID 83276

Submitted By: Golder Associates Inc.
18300 NE Union Hill Road, Suite 200
Redmond, WA 98052 USA

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1.0 INTRODUCTION

This report presents an assessment of potential source areas in the Upper Basalt Zone 2 (UBZ-2) at the Monsanto Soda Springs Idaho Plant (Plant). Monsanto has observed an overall decreasing concentration trend for the constituents of concern (cadmium, fluoride, manganese, nitrate, and selenium) in groundwater in the UBZ-2 source area. Recently, cadmium concentrations have increased in well TW-37 located near the old UFS ponds. In addition, there is evidence of short-term fluctuations in the constituents of concern in wells near the former coke and quartzite pond. Further, there are increasing concentrations of constituents of concern, particularly selenium and cadmium, in some wells and springs located downgradient of the Plant in both the UBZ-2 and UBZ-1 zones (Golder 2012a). Groundwater from new well TW-69 drilled west of the Plant and completed in UBZ-1 in 2011 contained concentrations of cadmium and selenium above the respective Remediation Goals (RGs) of 0.005 mg/L and 0.05 mg/L (Golder 2012a).

This report was prepared to provide information on the review of existing information on potential source areas in the UBZ-2 and other areas of the Monsanto Plant that potentially might influence the groundwater quality in the UBZ-2 and UBZ-1 zones and provide recommendations for field investigations and analysis. This report addresses Phase 1 (Historical Review) of the Work Plan (Golder 2011a).

This report addresses the following:

- Hydrogeologic conditions in the area of the known sources.
- History of operations and closure of the known source areas including review of historic topographic maps and aerial photographs.
- Nature and extent of any remaining source materials.
- Geochemical characterization of source materials and materials stockpiled based on existing data.
- Historic and present source area groundwater concentrations of the constituents of concern.
- Recommendations for additional field investigations.

1.1 Background

The Monsanto Soda Springs Plant (Plant) is located one mile north of the City of Soda Springs, Caribou County, Idaho (Figure 1-1). The site covers an area of approximately 800 acres, with the fenced plant site accounting for 540 acres.

Monsanto purchased agricultural land in 1952 to construct the Soda Springs elemental phosphorus production plant. The Plant uses locally mined phosphate ore. In 1984, Golder Associates Inc. (Golder) was retained to assess the impact of operations on groundwater and surface water quality at the Plant. The 1984 study found elevated concentrations of cadmium, selenium, fluoride and sulfate in groundwater beneath the Plant (Golder 1985). The sources of these constituents were determined to be the Old UFS Ponds, the Northwest Pond, and the Old Hydroclarifier. The investigation also concluded that groundwater under the southeastern portion of the plant contained elevated concentrations of vanadium, chloride, and sulfate. Based on groundwater flow directions and geochemical data, the elevated concentrations of these constituents in the southeastern portion of the Plant were attributed to the former Kerr-McGee Chemical Corporation (now Tronox) facility located to the east of the Plant, across Highway 34 from the Plant, and was further supported by findings from a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site inspection conducted in 1988 and supported by the results of the Remedial Investigation/Feasibility Study (RI/FS) activities completed at the Plant (Golder 1992a, 1995).

Monsanto conducted and submitted to the USEPA a Phase I RI in 1992 (Golder 1992a) and a Phase II RI in 1995 (Golder 1995). A Record of Decision (ROD) was signed by Monsanto and the USEPA in 1997. The selected remedy for groundwater is monitored natural attenuation. Bi-annual groundwater monitoring was in place from 1991 to 1994, and annual groundwater monitoring has occurred since 1995. Annual groundwater, surface water, and non-contact cooling water discharge monitoring is conducted at and near the Plant in order to ensure that natural attenuation is proceeding per modeled predictions (Golder 2003, 2008), and to monitor the natural attenuation process. Annual groundwater and surface water quality reports are prepared following completion of the annual sampling to evaluate groundwater quality and short-term groundwater quality trends. Long-term groundwater and surface water quality trends are statistically evaluated as part of the Five-Year Review process (Golder 2003, 2008).

Monsanto performed geophysical investigations and installed four new monitoring wells in 2007 (Golder 2006; 2007) to evaluate hydrogeologic conditions south of the Plant. Monsanto installed an additional eight monitoring wells south and west of the Plant in 2011 to further evaluate hydrogeologic conditions and groundwater quality (Golder 2012b)

An evaluation of natural attenuation in the UBZ-2 was completed in 2010 (Golder 2011b). The evaluation of natural attenuation indicated that concentrations of cadmium, fluoride, and manganese are controlled by the precipitation of mineral phases (otavite, fluorite, and rhodochrosite, respectively). Cadmium concentrations are also affected by the presence of chloride. As chloride concentrations in groundwater increase, the formation of cadmium-chloride complexes occurs and cadmium that may have been precipitated as cadmium carbonate (otavite) is remobilized. Increasing chloride concentrations as a result of runoff and infiltration of dust suppression chemicals (specifically magnesium chloride) have been observed in UBZ-2 at monitoring well TW-37 (Golder 2011b). Cadmium concentrations in TW-37 have increased over the same time period from about 0.326 mg/L in 2002 to 1.02 mg/L in 2011 (Golder 2012a).

Concentrations of nitrate and selenium in UBZ-2 are not controlled by mineral precipitation. These constituents are transported conservatively and concentrations of these constituents are affected by limited dispersion only (Golder 2011b).

1.2 Report Contents

This report includes several sections and appendices with supporting information:

- **Section 2** describes the hydrogeologic conditions in the UBZ at the Monsanto Plant, focusing on UBZ-2.
- **Section 3** describes the potential source areas in UBZ-2 and also in the adjacent parts of the UBZ (UBZ-1 and UBZ-4).
- **Section 4** provides information on groundwater quality in UBZ-2 in background wells and in source-area wells.
- **Section 5** describes potential source areas and mechanisms for mobilization of constituents from the source areas to groundwater.
- **Section 6** describes a conceptual model for the source areas in UBZ-2.
- **Section 7** provides recommendations for additional investigations.

Appendices A and B provide supporting information. Appendix A includes chemical hydrographs for UBZ-2 source area wells. Appendix B includes precipitation and groundwater elevation hydrographs.

2.0 HYDROGEOLOGY

This section describes the geologic and hydrogeologic conditions in the Plant area. Additional details on the geology and hydrogeology of the site are presented in the Phase I RI (Golder 1992a) and the Phase II RI/FS (Golder 1995).

2.1 Site Settings and Climate

The Monsanto Site is located about one mile north of the City of Soda Springs, Idaho (Figure 1). The site is bordered by agricultural lands to the north, west, and south. The area east of the Plant includes agricultural land and the Tronox (formerly Kerr-McGee) site.

Precipitation is measured at the Soda Springs Airport, about two miles southeast of the Plant at an elevation of 5,840 feet mean sea level (msl). Average water year (October 1 to September 30) precipitation over the period October 1980 to September 2011 is about 15.2 inches, and ranges from about 9 to 22 inches (Table 2-1). The average monthly rainfall is about 1 to 1.5 inches except in May when it is about 2.2 inches. Most of the precipitation falling in the months of November through March, inclusive, falls as snow. The average annual snowfall at the Soda Springs Airport is about 50 inches, however, winds cause significant areas of snow accumulation in drifts in some areas. There are two Sno-Tel stations near Soda Springs; Somsen Ranch at an elevation of about 6,800 feet, and Slug Creek Divide at an elevation of about 7,225 feet. At the nearby Sno-Tel stations, average water year precipitation over the period October 1981 to September 2011 is about 26.6 inches (Somsen Ranch) to 32.3 inches (Slug Creek Divide). The average snow water equivalent (SWE) at Somsen ranch is about 22.6 inches. At Slug Creek Divide, the average SWE is about 16.6 inches (Table 2-1). Snowmelt generally starts around the end of March and is usually completed by June 1 each year (Figures 2-1 and 2-2).

2.2 Geology

The geologic and hydrogeologic conditions at the Monsanto Plant have been investigated with about 70 monitoring wells (Golder 1995; 2007; 2012b), geophysical surveys (Golder 1995, 2006), and ongoing water quality monitoring. The locations of the monitoring wells are shown in Figure 2-3.

2.2.1 Surficial Deposits

The Monsanto Plant site is underlain by surficial deposits consisting of unconsolidated materials that are primarily loess with some sand and gravel. The thickness of the unconsolidated materials ranges from about 3 feet to 42 feet.

2.2.2 Blackfoot Lava Field

The Blackfoot Lava Field underlies much of the broad valley north of Soda Springs and the Bear River. The Blackfoot Lava Field consists of Quaternary-age individual basalt flows that are about 10 to 80 feet thick. The basalt flows are generally dense and unfractured. The basalt flows are separated by porous interflow zones consisting of sediments, broken and weathered basalt, and cinders. The interflow zones area about one to 23 feet thick.

2.2.3 Salt Lake Formation

The Tertiary Salt Lake Formation consists of tuffaceous sandstone, conglomerate, and limestone. The Salt Lake Formation is exposed north of the plant at Threemile Knoll.

2.2.4 Older Geologic Units

Older geologic units are exposed in the ranges bounding the Blackfoot Lava Field to the east and west. These units range in age from Triassic to Ordovician. The Aspen Range is on the east side of the valley, and the Soda Springs Hills on the west side of the valley. In the Aspen Range, sedimentary rocks including limestones, shales and sandstones occur. Quartzites and dolomites are exposed in the Soda Springs Hills. Limestones are also exposed at Threemile Knoll north of the plant.

2.2.5 Geologic Structures

Two prominent geologic structures cross the Plant site, the Monsanto Fault and the Subsidiary Fault (Figure 2-3). The Monsanto Fault is a northwest-trending hinge fault that has about 2 to 90 feet of displacement across the Plant site. The greatest displacement is found in the northwest corner of the Plant. South of the South Plant Fence Line, the displacement decreases to about 2 to 16 feet based on the offsets of interflow zones and individual basalt flows in wells TW-55 and TW-56. The Monsanto Fault appears to die out south of the Southern Boundary Wells based on the lack of topographic evidence and the results of geophysical surveys (Golder 1995; Golder 2006), however there are no wells located on the east side of the projection of the fault south of the Southern Boundary Wells to confirm this interpretation (Figure 2-3). The Subsidiary Fault is a hinge fault located about 1,500 feet west of, and parallel to, the Monsanto Fault. The displacement on the Subsidiary Fault is about 5 to 10 feet in the Plant area (Figure 2-3). The offset on the Subsidiary Fault decreases to the southeast. The Subsidiary Fault may extend south of the Southern Boundary Wells (Figure 2-3) to the area between wells TW-59 and TW-60 (Figure 2-3) based on the results of geophysical surveys and installation of new wells (Golder 2006; Golder 2007), and differences in groundwater quality in the 2007 monitoring wells (Golder 2012a). The geological interpretation of the interflow zones identified in the 2007 monitoring wells suggests that there is little displacement on the Subsidiary Fault south of TW-10 and TW-53 (Figure 2-3).

2.3 Hydrogeologic Units

The hydrogeology at the Monsanto Plant is presented in detail in Golder (1995), and was updated in Golder (2010). The primary hydrostratigraphic zones underlying the Monsanto Plant include the UBZ and the LBZ. The principal aquifer is the UBZ which extends to a depth of about 100 feet below ground surface (bgs) below the Plant and the area surrounding the Plant. The UBZ consists of up to three permeable interflow zones designated $\gamma3$, $\gamma4$, and $\gamma5$ that consist of cinders, broken and rubbly basalt, and sedimentary materials. The interflow zones are separated by lower-permeability basalt flows. Groundwater elevation data and pumping tests demonstrate a vertical hydraulic connection between the UBZ interflow zones (Golder 1995).

The depth to the water table ranges from 20 feet bgs in the northeast corner to 100 feet bgs in the center of the Plant. The Old UFS Ponds are located in the UBZ-2. In the vicinity of the Old UFS Ponds, groundwater is about 70 to 100 feet bgs. Groundwater flow in the UBZ and LBZ is a function of faulting, regional hydrogeologic conditions, and pumping of the plant production wells. The UBZ and LBZ are separated into smaller regions (designated UBZ-1 through UBZ-4 and LBZ-1 through LBZ-4), based on faulting, hydrogeological controls, and groundwater quality. The Old UFS Ponds are in UBZ-2. Details pertaining to the breakdown of UBZ and LBZ regions are provided in Golder (1992a) and Golder (1995).

2.4 Hydraulic Properties

2.4.1 Hydraulic Conductivity

Hydraulic conductivity of the basaltic sequence comprising the UBZ-2 source area was estimated by completing short-term (about one hour) pumping tests in several wells (TW-06 {now abandoned} and TW-57). Hydraulic conductivity data from UBZ-2 in the Old UFS area and in the area south of the Plant is summarized in Table 2-2. The short-term testing indicated the hydraulic conductivity in the Old UFS Ponds area (TW-6 and TW-57) was in the range of 300 to over 600 feet/day (ft/d). Other wells located along the South Plant Fence Line in UBZ-2 were also tested. The testing indicated a large range in hydraulic conductivity (from less than 1 ft/d to over 1,000 ft/d). The hydraulic conductivity of UBZ-2 is variable because of the thickness of the interflow zones varies across the site from about 1 to 23 feet, and the geologic materials in the interflow zones are variable.

2.4.2 Vertical Component of Hydraulic Gradient

The vertical component of hydraulic gradient in UBZ-1, UBZ-2, and UBZ-4 in the former source areas and downgradient wells in May 2011 is summarized in Table 2-3. In the Old UFS Ponds area, there is a downward component of vertical hydraulic gradient at wells TW-37 and TW-45 that varies from -0.017 feet/foot (ft/ft) to -0.041 ft/ft. The highest gradients are observed in the spring when groundwater recharge occurs. At wells TW-22, TW-23, and TW-24, the magnitude of the vertical component of hydraulic gradient is variable, ranging from about -0.011 ft/ft (downward) to 0.014 (upward). The slight vertical component of gradient does not vary seasonally.

There is an upward component of vertical hydraulic gradient at the South Plant Fence Line in the UBZ-1 and UBZ-2 areas. At wells TW-35 and TW-39 at the South Fence Line (UBZ-2), there is an upward component of hydraulic gradient ranging from 0.065 ft/ft to 0.101 ft/ft. The vertical component of hydraulic gradient is slightly greater in the spring than in the fall. In wells TW-19, TW-20, TW-21, and TW-34 located at the South Fence Line (UBZ-2), the upward component of vertical hydraulic gradient varies from about 0.054 ft/ft to 0.141 ft/ft. The vertical component of gradient does not vary in direction seasonally.

The vertical component of hydraulic gradient in UBZ-1 at the South Plant Fence Line was evaluated using wells TW-07 (UBZ), TW-08 (UBZ), TW-09 (LBZ), and TW-10 (UBZ) located in the southeast corner of the Plant (Figure 2). The groundwater elevations at this location indicate that over most of the monitoring period, an upward component of hydraulic gradient between the LBZ and UBZ exists at this location. The magnitude of the upward component of hydraulic gradient varied between about 0.002 ft/ft and 0.040 ft/ft. The vertical component of hydraulic gradient is generally greater in the spring and lower in the fall and winter. The upward component of hydraulic gradient is consistent with observations of groundwater discharge in UBZ-1 from springs such as Calf Spring, Southwest Spring, and Mormon A, B, and C Springs.

2.5 Groundwater Flow

In the UBZ, groundwater flow in May 2011 is predominantly from north to south (Figure 2-4), similar to previously observed groundwater flow patterns. In the northeast corner of the Plant, groundwater flows into the Plant area from the northeast. The four production wells (PW-01, PW-02, PW-03, and PW-04) create two areas of depressed groundwater levels. One area of depressed water levels occurs surrounding PW-04 at the north end of the Plant, and a second area occurs surrounding PW-01, PW-02, and PW-03 located in the center of the Plant.

Groundwater flow at the southern boundary of the Plant is in a southerly direction. Groundwater eventually begins to flow southwest across the southern trace of the Subsidiary Fault toward Mormon Creek and Soda Creek. Groundwater discharges to the head of Mormon Creek at Mormon Springs (A, B, and C) and Calf Spring. Groundwater subsequently discharges as diffuse seepage along the remainder of the Mormon Creek channel and to the Soda Creek channel.

The Monsanto Fault appears to act as a barrier to groundwater flow over most of its length in the Plant area based on groundwater elevations in the Plant area, pumping tests completed in TW-58 at the South Plant Fence Line, and response to pumping of the Plant production wells.

Pumping tests completed in TW-58 at the South Plant Fence Line indicted the Subsidiary Fault acts as a groundwater flow barrier at the South Plant Fence Line (Golder 1995). Groundwater quality data from the Harris Well and Mormon A Spring suggests the Subsidiary Fault allows discharge of water from UBZ-2 to UBZ-1 south of the South Plant Fence Line. North of the South Plant Fence Line, the Subsidiary Fault appears to allow some discharge of UBZ-2 groundwater to UBZ-1 between the Old UFS Ponds and the

South Plant Fence Line, based on water quality in TW-10, TW-69, and Southwest Spring (Golder 2012a; 2012b).

2.5.1 Groundwater Velocity

Concentrations of conservative constituents including nitrate, chloride, selenium, sulfate, and molybdenum at the source area (Old UFS Ponds) and downgradient wells in UBZ-2 were used to evaluate the groundwater velocity and hydraulic conductivity. An interflow zone effective porosity of 30% was assumed when estimating the hydraulic conductivity.

The overall groundwater velocity in the UBZ-2 is estimated to be about 1 to 2 ft/d, with a mean estimated velocity of 1.3 ft/d. There appear to be localized areas with higher groundwater velocities such as the area between wells TW-20 and TW-54 based on "lock-step" concentration trends for conservative constituents (Golder 2012c). The hydraulic conductivity in UBZ-2 was estimated to range from about 33 to 220 ft/d based on the groundwater velocity and an assumed effective porosity of 30%. The mean estimated hydraulic conductivity is 61 ft/d. This is generally consistent with estimates of hydraulic conductivity from single-well tests in UBZ-2 wells (Table 2-2). The hydraulic conductivity estimated from the groundwater quality reflect the bulk permeability of the UBZ-2 better than the single-well tests, which likely reflect the hydraulic conductivity within a limited area around the well.

2.6 Hydrology

Soda Creek is the principal surface drainage in the vicinity of the Plant. Soda Creek originates at Fivemile Meadows about four miles northwest of the Plant. Soda Creek flows west of the Plant and discharges to Alexander reservoir in the Town of Soda Springs. South of the Plant site, most of the flow in Soda Creek is diverted for hydropower and irrigation.

South of the Plant site, there are several springs that discharge to Soda Creek. These springs include:

- Southwest Spring
- Mormon A, B, and C Springs
- Homestead Spring
- Calf Spring
- Doc Spring
- Numerous small unnamed springs

Discharge from the springs ranges from about one cubic foot per second (448 gpm) at Southwest Spring to a few gallons per minute at Calf, Mormon B and C Springs, and Homestead Springs. The discharge from Mormon A, B, and C Springs, along with diffuse groundwater seepage, forms Mormon Creek, a small tributary to Soda Creek (Figure 2-3).

2.7 Stormwater Management

At the Monsanto Plant site, stormwater runoff from the Plant roads generally runs off the roads and collects in low-lying areas and infiltrates, or infiltrates from the road surface. During the winter months, Monsanto plows snow from the Plant roads. Some of the snow is stockpiled on the northwest side of the Plant site.

During spring snowmelt, Monsanto has observed ponding of water along Threemile Knoll Road on the west side of the Plant (Figure 2-3 and 3-7). The water ponded along the road likely originates as snowmelt runoff from the agricultural areas west and northwest of the Monsanto Plant, and from snowmelt from the west side of the Plant site.

3.0 POTENTIAL SOURCE AREAS

This section describes potential source areas at the Monsanto Plant in UBZ-2 and also in UBZ-4 that have potential to impact groundwater in UBZ-2. The potential source areas in the UBZ-1 area are also discussed because sources in both the UBZ-2 and UBZ-1 have the potential to affect groundwater quality in UBZ-1.

Table 3-1 provides a chronology of the potential source areas based on aerial photographs and topographic maps over the period 1970 through 2011. The locations of the potential source areas are shown on Figure 3-1. The potential source areas are:

- UBZ-2
  - Old Underflow Solids Ponds
  - Materials Stockpiles
  - Former Unidentified Disposal Area
  - Former Coke and Quartzite Dust Settling Pond
  - Former Effluent Settling Pond
  - Former Sewage Evaporation Ponds
  - Slag
- UBZ-4
  - Old Hydroclarifier Northwest Pond
  - Underflow Solids Ponds Materials Stockpiles
  - Coke and Quartzite Stockpiles
- UBZ-1
  - Slag
  - Former Coke and Quartzite Dust Settling Ponds
  - Former Sewage Evaporation Ponds

3.1 UBZ-2 Source Areas

3.1.1 Old Underflow Solids Ponds

The Old Underflow Solids Ponds (UFS) Ponds were located on the west side of the Plant (Figure 3-1). There were two ponds in operation from at least 1970 through 1985. The depth of the two ponds is uncertain, however, a 1970 topographic map shows excavation to an elevation of 5,936 feet msl. Assuming the original ground surface elevation at the southern Old UFS Pond was about 5,957 feet (based on the ground surface elevation at TW-37), this suggests the depth of the southern pond was at least 21 feet deep. The materials present at the base of the pond are uncertain, the geological log of TW-37 shows silty clay extending to a depth of about five feet bgs, and weathered basalt extending to a depth of 13 feet bgs. Therefore, the pond was most likely excavated into the top of the basalt.

Underflow solids are fine-grained materials from the rotary kiln that are blown out of the kiln and removed using a spray tower scrubber and high-energy venture scrubbers. The underflow solids slurry was directed into one of two ponds for dewatering. Dewatering of the slurry occurred as the fluid portion of the slurry infiltrated. When the underflow solids were dewatered, the solids were excavated and returned to the furnaces for further processing.

The Old UFS Ponds were closed in 1987. The ponds were closed by excavating most of the remaining underflow solids and recycling them in the furnace, filling the ponds with molten slag, and capping the ponds with a bentonite cap. Crushed slag was placed over the bentonite cap. Approximately 35,000 tons of underflow solids were estimated to have remained in the ponds when they were closed and capped. The ponds covered a combined area of about 556,600 square feet. Assuming a specific gravity of 2.7 grams/cubic cm for the underflow solids, or 0.084 ton/cubic foot (Golder 1995), this is equivalent to a residual thickness of underflow solids of about 0.75 feet across the extent of the ponds.

Information on the appearance and operation of the Old UFS Ponds based on aerial photographs and topographic maps is summarized in Table 3-1. The aerial photographs and topographic maps show the Old UFS Ponds in operation in 1970 (topographic map – Figure 3-2), 1974 (aerial photograph - Figure 3-3), and 1985 (aerial photograph - Figure 3-4). In 1970, the northern pond had standing water at an elevation of 5,961 feet msl, while the southern pond did not have standing water. The southern pond had excavations to an elevation of 5,936 feet msl. The groundwater elevation in TW-37 ranges from 5,885 to 5,893 feet msl. The Old UFS Ponds and remaining underflow solids are therefore above the water table.

The 1974 air photo shows the northernmost pond being used for dewatering, while the southern pond is being excavated (Figure 3-3). The 1985 aerial photo shows excavation activity in both ponds, with no standing water (Figure 3-4).

The 1991 Plant topographic map and the 1992 aerial photograph (Figure 3-5) show the Old UFS Ponds are closed and covered. Later aerial photos and topographic maps show the portions of the area of the Old UFS Ponds being covered with crushed slag based on visual examination of the fill materials. The top of the crushed slag fill is used as an equipment laydown and material stockpile (Figure 3-6). The locations of cross sections through UBZ-2 are shown in Figure 3-7. The crushed slag fill is about 35 to 70 feet thick based on cross sections through the Old UFS ponds area and comparisons of the 1970 and 2011 topography (Figures 3-8 and 3-9).

The Old UFS Ponds represent both primary and secondary sources of potential constituents. The primary source is the remnant underflow solids remaining at the base of the pond following closure. The secondary source is minerals precipitated in the unsaturated zone below the Old UFS Ponds as the result of downward migration of infiltrating precipitation during pond operations. These minerals likely include otavite, rhodochrosite, and fluorite. Speciation modeling and saturation indices (Golder 2011b) suggested groundwater was in equilibrium or oversaturated with otavite, rhodochrosite, and fluorite in the area of the Old UFS Ponds, likely resulting in precipitation of these minerals in the UBZ groundwater near the Old UFS Ponds.

3.1.1.1 Underflow Solids Geochemical Characterization

The Old UFS ponds were closed in 1986, prior to the start of the RI/FS characterization activities. Underflow solids from stockpiles at the Plant Site were characterized as part of the Phase I RI/FS (Golder 1992a) and the Phase II RI/FS (Golder 1995). The underflow solids in the stockpiles are settled and dewatered in the Hydroclarifier and then run through a belt filter press for further dewatering prior to being stockpiled.

The underflow solids were characterized in both the minus 200 sieve fraction and the total fraction. The minus 200 fraction contained 1,313 mg/kg cadmium and 208 mg/kg selenium, while the total fraction contained 1,197 mg/kg cadmium and 169 mg/kg selenium (Table 3-1). Other constituent concentrations in the underflow solids are:

- Fluoride – 227 mg/kg (-200 mesh sample) and 623 mg/kg (total sample).
- Manganese - 179 mg/kg (-200 mesh sample) and 93 mg/kg (total sample).
- Molybdenum - 36 mg/kg (total sample).

3.1.2 UBZ-2 "Tailings" Pond

The 1970 topographic map (Figure 3-2) designates an area between the Old UFS Ponds and the two coke and quartzite ponds shown on the 1974 and 1985 aerial photographs (Figures 3-3 and 3-4, respectively) as a "tailings pond". A similar designation is given to the two coke and quartzite settling ponds visible on the 1974 and 1985 aerial photographs. Wells TW-22, TW-23, and TW-24 are installed in the area designated as a tailings pond north of the two former coke and quartzite ponds. Review of the geologic logs for these three wells (Golder 1985) indicates about 16 feet of brown/black silty sand described as "tailings" were intersected from about 4 to 20 feet below ground. Geochemical characterization data are not available for these materials. There is no information on the closure of this pond. The pond footprint is in part covered with crushed slag fill and molten slag dating to at least 1970 (Figure 3-2). Monsanto uses the top of the crushed slag fill as an equipment laydown and storage area (Figure 3-6).

Review of groundwater quality data from TW-37, TW-22, and TW-24 (Section 5) suggests that there may be an unidentified source area between the Old UFS Ponds and TW-22 and TW-24 based on observed concentrations of molybdenum and sulfate, both of which occur at higher concentrations in TW-22 and TW-24 than in TW-37. Further, the area may be the source of short-term pulses of constituents during wetter periods including cadmium, fluoride, nitrate (Figure A-7, Appendix A) and selenium, chloride, molybdenum and sulfate (Figure A-8, Appendix A). This source area may be the "tailings pond" north of the coke and quartzite ponds and south of the Old UFS Ponds.

3.1.3 Material Stockpiles

Monsanto stockpiles various materials in UBZ-2 on top of areas filled with crushed slag (Figure 3-7). The materials stockpiled or used for fill include:

- A portion of the calcium silicate slag pile is in UBZ-2. Molten calcium silicate slag from the furnaces is transported to the slag pile where it is poured. The slag then cools and forms a solid mass. Molten slag was also used to fill the Old UFS Ponds in UBZ-2.
- Some slag from the slag pile is crushed and used for fill and stockpiled for general use at the Plant. The laydown areas in UBZ-2 are all on crushed slag fill.
- Quartz sand (fine quartzite) and cinders used for general use at the Plant and as traction material in the winter. These materials are spread throughout the Plant roads in the winter.
- Treater dust is fine-grained material separated by electrostatic precipitators as phosphorus gas is condensed to a liquid. Any residual phosphorus in the treater dust is oxidized in a chamber before the materials are stockpiled.
- Nodules fines piles are fine nodules resulting from the nodulizing of the phosphate ore in the kiln. The nodule fines are recycled in the kiln with the phosphate ore during the beneficiation process.
- Excavated clean soils from Plant construction projects.
- Snow removed from Plant roads is stockpiled during winter months.

The locations of the materials stockpiled in UBZ-2 are shown in Figure 3-7.

3.1.3.1 Geochemical Characterization

Analyses of the source materials stockpiled in UBZ-2 completed as part of the RI/FS investigations are summarized in Table 3-2. Monsanto has also characterized various ore beneficiation products and byproducts (Table 3-3).

The materials characterization indicated:

- The calcium silicate slag contains low concentrations of selenium (about 1.2 to 2.4 mg/kg) and cadmium (15 to 21 mg/kg; Table 3-2). The calcium silicate slag also contains low concentrations of fluoride, manganese, and molybdenum. The calcium silicate slag passed Toxic Characteristic Leach Procedure (TCLP) testing with cadmium and selenium concentrations of 0.032 mg/L and <0.0035 mg/L, respectively (Table 3-4, Golder 1995), below the TCLP Maximum Contaminant Levels (MCLs) of 1.0 mg/L for both cadmium and selenium.
- The quartzite contained very low to non-detect concentrations of selenium and cadmium (0.26 mg/kg and less than 0.2 mg/kg, respectively; Tables 3-2 and 3-3). Manganese (less than 9.6 mg/kg) and molybdenum (less than 0.86 mg/kg) were also not detected (Table 3-2).

- There was no characterization of the basalt cinders completed as part of the RI/FS; however, the basalt cinders are not expected to be a source of selenium, cadmium, or other constituents of concern.
- Treater dust was characterized in the minus 200 sieve fraction (old treater dust) and the total fraction (new treater dust). The old treater dust contained 131 mg/kg cadmium and 33 mg/kg selenium. In comparison, new treater dust contained 40 mg/kg cadmium and 13 mg/kg selenium (Tables 3-2 and 3-3). The treater dust passed TCLP testing with cadmium and selenium concentrations of 0.033 mg/L and <0.0035 mg/L, respectively (Tables 3-4, Golder 1995). Treater dust contains high concentrations of fluoride (up to 25,000 mg/kg; Table 3-3) and low concentrations of manganese and molybdenum.
- Nodules contained 11 mg/kg cadmium and 1.6 mg/kg selenium (Tables 3-2 and 3-3). Analyses by Monsanto (Table 3-3) indicate the nodules are high in fluoride (up to 102,000 mg/kg) and low in manganese and molybdenum. Analyses completed as part of the RI/FS work (Table 3-2) indicated lower fluoride concentrations (total fraction - 13 mg/kg, – 200 sieve fraction - 30 mg/kg).

3.1.4 Crushed Slag Fill

Monsanto crushes some of the calcium silicate slag that was placed in molten form on the slag pile. The crushed slag is used for a variety of uses around the Plant area including fill and road base. Crushed slag was used to fill a large area in the vicinity of the Old UFS Ponds. The slag fill is estimated to be about 35 to over 70 feet thick (Figures 3-8 and 3-9). Large areas east, south, and north of the Old UFS Ponds appear to be filled with slag on the 1970 topographic map. The area of slag fill north of the Old UFS Ponds increases with time as shown on the aerial photographs (Figures 3-4 through 3-6, inclusive). Most of the area north of the Old UFS Ponds and east of Government Dam Road is presently filled with slag (Figure 3-6).

3.1.5 Unidentified Disposal Area

Maps presented in the Phase I RI Report (Golder 1992a), the Phase II PI Work Plan (Golder 1992b), and the Phase II RI (Golder 1995) all show an area located about 500 feet north of the northernmost Old UFS Pond as a former unidentified disposal or dumping area (Figure 3-1). This area is now under crushed slag fill estimated to be about 40 to 50 feet thick. There has been no characterization of any materials that may have been disposed of in this area. This area appears to have been filled with crushed slag between about 1985 and 1998 based on aerial photographs and topographic maps.

3.2 UBZ-4 Source Areas

3.2.1 Old Hydroclarifier

The Old Hydroclarifier was used to treat and settle kiln dust (underflow solids), phossy water, and treated scrubber blowdown. The Old Hydroclarifier was constructed with an open bottom and was identified to be a potential source in 1984 (Golder 1985). The Old Hydroclarifier was replaced with lined new hydroclarifier with a leachate collection system in 1985.

3.2.2 Northwest Pond

The Northwest Pond was constructed between 1956 and 1964 as a backup for the Old Underflow Solids Ponds. The Northwest Pond was not used for storage or dewatering of underflow solids, however, process water was stored in the pond periodically when the Old Hydroclarifier was out of service for maintenance. Process water or some other source of water is visible in the Northwest Pond in the 1974 aerial photograph (Figure 3-3). The Northwest Pond was used until 1983, when it was taken out of service.

The Northwest Pond was excavated and bentonite placed over the base of the pond in 1986. The excavated materials were placed in the Old UFS Ponds prior to closure. The Northwest Pond is currently permitted as a solid waste landfill for the Plant.

3.2.3 Underflow Solids Ponds

There were six linear ponds shown on the 1970 topographic map (Figure 3-2) and the aerial photograph from 1974 located immediately southwest of the Northwest Pond (Figure 3-3). On maps presented in the Phase I and Phase II RI/FS Reports (Golder 1992a, Golder 1995) these ponds are labels as Old UFS Ponds. The topographic map and aerial photo show water in some of the ponds at elevations of 5,985 to 5,990 feet msl, and pond base elevations for the ponds without water of about 5,981 feet msl. The base of the ponds is about 45 to 50 feet above the groundwater elevation in wells TW-16 and TW-17 of about 5,933 feet msl, or about 50 feet below the base of the pond.

There is no information on the closure of these ponds. The 1985 aerial photograph (Figure 3-4) shows the area of the ponds to be covered with stockpiled underflow solids and nodules.

The Northwest Pond, Old Hydroclarifier, and Old UFS ponds may represent both primary and secondary sources of potential constituents. The primary sources may be any remnant materials remaining in the NW Pond, Old UFS Ponds, or Old Hydroclarifier following closure. The secondary sources may be minerals precipitated in the unsaturated zone below these areas as the result of downward migration of infiltrating precipitation. These minerals likely include otavite, rhodochrosite, and fluorite. Speciation modeling and saturation indices (Golder 2011b) suggested groundwater was in equilibrium or oversaturated with otavite, rhodochrosite, and fluorite in the area of Northwest Pond and Old Hydroclarifier, likely resulting in precipitation of these minerals near the former source areas.

3.2.4 Materials Stockpiles

Monsanto stockpiles several raw materials for the furnace overlying the UBZ-4. These include two ore blends, quartzite, and coke. In addition, various byproducts from the ore beneficiation process are stockpiled in UBZ-4, including underflow solids, nodules, treater dust, and baghouse dust (Figure 3-6). A portion of the slag pile where molten slag from the furnaces is deposited is also in UBZ-4.

3.2.4.1 Geochemical Characterization

Samples were collected from various material and byproduct stockpiles in UBZ-4 as part of the Phase I and Phase II RI activities between 1991 and 1993.

- Samples from underflow solids were collected from six locations from the underflow solids stockpile in the northeast corner of the Plant. The underflow solids were characterized in both the minus 200 sieve fraction and the total fraction. The minus 200 fraction contained 1,313 mg/kg cadmium and 208 mg/kg selenium, while the total fraction contained 1,197 mg/kg cadmium and 169 mg/kg selenium (Table 3-2).
- Treater dust was sampled from six locations in the treater dust stockpile. Treater dust was characterized in the minus 200 sieve fraction (old treater dust) and the total fraction (new treater dust). The old treater dust had 131 mg/kg cadmium and 33 mg/kg selenium. In comparison, new treater dust had 40 mg/kg cadmium and 13 mg/kg selenium (Tables 3-2 and 3-3). The treater dust passed TCLP testing with cadmium and selenium concentrations of 0.033 mg/L and <0.0035 mg/L, respectively (Table3-4, Golder 1995).
- Monsanto stockpiles ore blends in UBZ-4. The ore is stockpiled in two stockpiles depending on the ore grade. Blend 1 is the higher grade ore and accounts for about 67% of the stockpiled material. Ore blend 1 contained 121 mg/kg cadmium and 46 mg/kg selenium (minus 200 fraction). For the total fraction, ore blend 1 has 120 mg/kg cadmium and 28 mg/kg selenium (Tables 3-2 and 3-3). Ore blend 2 contained slightly higher in cadmium (132 mg/kg for the -200 fractions and total) and selenium (65 mg/kg and 41 mg/kg for the -200 mesh and total fractions). Nodules are ore that has gone through the kiln and are expected to have similar composition as the ore.
- Quartzite and coke are stockpiled in UBZ-4. The quartzite contained 0.026 mg/kg cadmium and less than less than 0.2 mg/kg selenium (Tables 3-2 and 3-3). The coke contained less than 3.8 mg/kg cadmium (minus 200 fraction) and less than 9.6 mg/kg (total). Selenium concentration in the coke were 1.3 mg/kg (minus 200 fraction) and 0.39 mg/kg (total).
- Baghouse dust contained 211 mg/kg cadmium and 0.40 mg/kg selenium (minus 200 mesh fraction, Table 3-2). Monsanto also characterized materials in several baghouses (Table 3-3). The baghouse material contained up to 4 mg/kg cadmium and 59 mg/kg selenium.

3.3 UBZ-1 Source Areas

There were several ponds located in the southwest corner of the Plant in UBZ-1 used for settling and dewatering of coke and quartzite dust slurry, effluent (non-contact cooling water) settling and cooling, and sewage evaporation (Figure 3-1). A portion of the calcium silicate slag pile is also located over UBZ-1.

The coke and quartzite ponds were used to dewater coke and quartzite slurry from the old wet scrubber system. The 1970 topographic map (Figure 3-2) shows three ponds may have been used at one point for dewatering, but the 1974 and 1985 aerial photographs (Figures 3-3 and 3-4, respectively) show two ponds in use. The ponds were taken out of service in 1987 when a coke and quartzite dryer was installed. The former ponds are shown on the 1991 topographic map, but by 1992 they appear to have been filled (Figure 3-5), and by 1998 they are partially covered with slag as the molten slag pile expanded.

The effluent settling pond was used to settle and cool con-contact cooling water prior to discharge at the outfall in Soda Creek. The non-contact cooling water was sourced from three Plant production wells (PW-01, PW-02, and PW-03). The non-contact cooling water did not come into contact with any of the phosphorus production materials or byproducts. Therefore, groundwater is the source of constituents in the non-contact cooling water. The non-contact cooling water and raw water from the Plant production wells is characterized as part of the annual water quality sampling. The effluent pond was taken out of service sometime between 1995 and 1998, and was eventually filled with molten slag as the slag pile expanded.

Two sewage evaporation ponds were located in the southwest corner of the Plant (Figure 3-1). The ponds were used to treat sanitary wastewater from the Plant. The wastewater was treated using biodegradation and settling. Wastewater from the ponds eventually infiltrated, evaporated, or was applied to nearby fields as fertilizer. The ponds were used until the fall of 1993, when sanitary wastewater was routed to the City of Soda Springs wastewater treatment plant. The ponds were eventually filled with molten slag as the slag pile expanded.

The former coke and quartzite settling pond sediments, sediment in the former effluent settling pond, and sediment in the former sewage evaporation ponds likely represent primary sources. Speciation modeling and saturation indices (Golder 2011b) suggested that otavite and rhodochrosite were undersaturated in UBZ-1 groundwater near the coke and quartzite settling pond, while fluorite may be at equilibrium. Thus, there is limited potential for secondary sources in the aquifer.

3.4 Dust Control Activities

Monsanto applies dust control materials to roads in the Plant in order to reduce fugitive dust emissions. The locations of dust control application are shown in Figure 3-10. Magnesium chloride was used between at least 1999 and 2007 for dust control. From 1999 through 2006, two applications were made every year. Beginning in 2007, magnesium chloride was applied three times per year. Following application of magnesium chloride, water was used for dust control. The amount of water applied per day varied depending on the freshness of the magnesium chloride application. If the application was recent, as little as three hours of watering per day was necessary. Over time, this increased to 16 to 18 hours of watering per day.

The use of magnesium chloride was discontinued at the end of 2009 because of concerns about increasing chloride concentrations in groundwater and mobilization of cadmium as cadmium-chloride complexes (Golder 2011). Lignosulfonate (GE DusTreat 9112T) was used for dust control in 2010, but not in 2011 or 2012 when water was used for dust control.

3.5 Source Area Assessment

Table 3-5 summarizes the potential source areas and the associated constituents of concern and other constituents (chloride, molybdenum, and sulfate) for each potential source area under evaluation.

In UBZ-2, the Old UFS Ponds are a known source of groundwater contamination for the constituents of concern. The potential sources include both remnant underflow solids remaining in the ponds following closure and minerals precipitated in the vadose zone below the pond. The Old USF Ponds were closed in 1987.

The pond shown as a "tailings pond" located north of the coke and quartzite ponds and south of the Old UFS Ponds (Figure 3-2) appears to be a source of the constituents of concern and molybdenum and sulfate. There is no information on the closure of the pond, which is covered with crushed slag fill. The pond appears to be out of service by 1970, as the approximate pond area appears to be in part covered with crushed slag fill (Figures 3-2 and 3-3).

There are also materials stockpiled in UBZ-2 that are potential sources for the constituents of concern and other constituents. Based on the geochemical characterization, the treater dust and nodules stockpiled in UBZ-2 may be potential sources of fluoride.

Based on the geochemical characterization, the following materials do not appear to be sources of potential groundwater contamination:

- Molten Slag
- Crushed slag
- Sand
- Cinders
- Stockpiled clean soils and snow

In UBZ-4, the Northwest Pond and the Old Hydroclarifier are known sources for the constituents of concern. The potential sources include both remnant materials remaining in the Northwest Pond or Old Hydroclarifier area following closure, and minerals precipitated in the vadose zone below the ponds. The Northwest Pond was converted to a permitted landfill in 1987, and the Old Hydroclarifier was replaced with a new lined facility in 1985. The Old UFS Ponds in UBZ-4 may also represent a potential source of constituents of concern. There is no information on the closure of the UBZ-4 Old UFS Ponds. There are also materials stockpiled in UBZ-4 that are potential sources for the constituents of concern and other constituents:

- The UFS Piles may be potential sources of cadmium, fluoride, manganese, and selenium.
- Treater dust is a potential source of fluoride.

Since groundwater in the UBZ-4 is captured by the Plant Production Wells (PW-1, PW-3 and PW-3), any groundwater affected by these sources is captured.

In UBZ-1, there are several former ponds including the coke and quartzite dust slurry pond, effluent settling pond, and the sewage evaporation ponds that may have been sources of constituents of concern. These ponds have all been taken out of service in the late 1980s to early 1990s and were filled with molten slag.

The following UBZ-1 source areas may have been potential sources of constituents of concern:

- The sewage evaporation pond may have been a potential source of nitrate.
- The effluent settling pond may have been a source of constituents of concern, however, the water quality in the effluent cooling pond was likely similar to the groundwater quality from Plant Production Wells PW-01, PW-02, and PW-03. With the exception of cadmium in PW-01 and PW-02 and selenium in PW-01, concentrations of the constituents of concern in the Plant wells are below remediation goals.

The following UBZ-1 source areas and material stockpiles are likely not potential source areas for UBZ-2:

- The materials dewatered in the coke and quartzite settling pond (coke and quartzite) contain low concentrations of cadmium, fluoride, manganese and selenium based on the geochemical characterization.

Molten slag and crushed slag fill do not appear to be sources of constituents of concern based on geochemical characterization.

4.0 GROUNDWATER QUALITY

Groundwater quality in the area of the Old UFS ponds is described in annual water quality reports (for example, Golder 2012a, b, and c). Groundwater quality in the area of the Old UFS Ponds is monitored at several locations (Figure 2):

- TW-57 located west of the Plant serves as a background groundwater quality monitoring location. TW-57 is completed in the γ4 interflow zone of the UBZ-2.
- TW-37 and TW-45 are located on the west side of the southern Old UFS Pond. TW-37 is completed in the γ3 zone of the UBZ-2 while TW-45 is completed in the LBZ-2. Well TW-37 is the closest well to the Old UFS Ponds source area but was not installed in the source or directly downgradient.
- Wells TW-22, TW-23, and TW-24 are located about 1,200 feet downgradient of the Old UFS Ponds on the West Plant Fence Line. TW-22 and TW-24 are completed at differing depths within the UBZ-2 γ4 interflow zone, while TW-23 is completed in the LBZ-2.
- Well TW-26 is located east of the Old UFS Ponds, east of the Monsanto Fault, in the UBZ-2. TW-26 is completed in the γ2 interflow zone.

These wells have been sampled since 1991 (with the exception of TW-57 which was first sampled in 1994). In addition to these wells, Monsanto installed two new wells in UBZ-1 west of the west Plant Fence Line which were first sampled in 2011 (TW-68 and TW-69).

Concentration trends for the constituents of concern and chloride, molybdenum, and sulfate are discussed in annual water quality reports such as Golder (2012a). Statistical analyses of concentration trends are performed as part of the 5-Year review process (Golder 2003; 2008). The next 5-Year review is scheduled for 2013.

4.1 TW-57 – UBZ-2 Background

Chemical hydrographs for TW-57 for the constituents of concern and chloride, sulfate, and molybdenum are included in Attachment A. The following summarizes the constituents of concern:

- Cadmium has not been detected in TW-57 (generally less than 0.0005 mg/L, Figure A-1).
- Fluoride is stable and generally less than 0.5 mg/L (Figure A-1).
- Manganese has generally not been detected in TW-57 (generally less than 0.001 mg/L, Figure A-1).
- Nitrate (as N) is stable and ranges from about 0.5 to 2 mg/L-N (Figure A-1), although higher concentrations of nitrate have been observed in other background wells at the Plant such as TW-29 (about 5 mg/L-N) and the SO_2 North well (about 15 to 20 mg/l-N).
- Selenium concentrations are stable and have ranged from less than 0.003 mg/L to about 0.006 mg/L (Figure A-2).
- Concentrations of chloride and sulfate are stable, and molybdenum is generally not detected (Figure A-2).

4.2 TW-37 and TW-45 - Old UFS Ponds

Chemical hydrographs for TW-37 (UBZ) and TW-45 (LBZ) for the constituents of concern and chloride, sulfate, and molybdenum are included in Attachment A. The following summarizes the constituents of concern in TW-37 completed in the UBZ:

- Cadmium has been increasing in TW-37 since about 2002 when a concentration of 0.326 mg/L was measured (Figure A-3). The cadmium concentration was 1.02 mg/L in 2011, and decreased to 0.626 mg/L in 2012. Chloride concentrations show a similar increase (Figure A-4) as a result of infiltration of magnesium chloride dust suppressant. Cadmium concentrations remain below historic high concentrations observed in the 1980's (Golder 2012a).
- Fluoride is gradually decreasing and is 8.08 mg/L in 2012 (Figure A-3).
- Manganese is stable at about 0.5 to 0.7 mg/L and has decreased since historic high concentrations were observed in the early 1990's (Figure A-3).
- Nitrate (as N) is increasing slightly in TW-37 at concentrations of about 8 to 12 mg/L (as N) but remains below historic high concentrations observed in the late 1980's (Figure A-3).
- Selenium concentrations are decreasing since historic high concentrations were observed in the early 1990s and have ranged from about 0.2 to 0.4 mg/L over the past (Figure A-4) few years.
- Concentrations of chloride are increasing (Figure A-4), similar to cadmium. Chloride concentrations increased from 25 mg/L in 2002 to 649 mg/L in 2011. The 2012 chloride concentration is 288 mg/L.
- Concentrations of molybdenum have been steadily decreasing since the early 1990's with a 2012 concentration of 0.232 mg/L.
- Concentrations of sulfate are increasing slightly (Figure A-4). The 2012 sulfate concentration of 354 mg/L remains below historic high concentrations observed in the late 1980's.

Well TW-45 is completed in the LBZ. As shown in Figures A-5 and A-5, concentrations of the constituents of concern and chloride, sulfate, and molybdenum are all stable or decreasing.

4.3 TW-22, TW-23, and TW-24 - Downgradient Old UFS Ponds

Wells TW-22 and TW-24 are completed in the UBZ-2 γ4 interflow zone downgradient of the Old UFS Ponds. TW-24 is the shallower of the two wells with a screen from 82 to 92 feet below ground, while TW-22 is slightly deeper (107 to 112 feet below ground).

- Cadmium is stable in both wells, and remains below historic high concentrations observed in the 1980's (Golder 2012a). Cadmium concentrations are higher in TW-24 (about 0.25 to 0.3 mg/L) compared to TW-22 (about 0.025 mg/L, Figure A-7).
- Fluoride concentrations in both wells are similar at about 3 to 5 mg/L and have gradually decreased since historic high concentrations were observed in the mid to late 1990's (Figure A-7).

- Manganese is stable in TW-24 at about 0.25 mg/L and gradually decreasing from historic high concentrations of about 1.8 mg/L to a 2012 concentration of 0.75 mg/L in TW-22. Manganese concentrations in both wells have decreased since historic high concentrations were observed in the early 1990's (Figure A-7).
- Nitrate (as N) concentrations in both wells are similar at about 4 to 5 mg/L (as N) and remain below historic high concentrations of 8 to 16 mg/L (as N) observed in the late 1980's (Figure A-7).
- Selenium concentrations in both wells are decreasing since historic high concentrations were observed in the early 1990s (Figure A-8). However, selenium concentrations in both wells show short-term increases in concentration. The 2012 selenium concentrations in TW-22 and TW-24 are 0.17 mg/L and 0.408 mg/L, respectively.
- The concentration of chloride in TW-22 is stable at about 30 to 40 mg/L, and has decreased since historic high concentrations of 200 to 300 mg/L were observed in the mid to late 1980s. In TW-24, chloride concentrations are generally decreasing since the historic high concentrations observed in the mid-1980s, except for a short-term increase in TW-24 (Figure A-8). The short-term increase observed in TW-24 in 2005 and 2006 was not observed in source area well TW-37. The 2012 chloride concentrations are 44 mg/L in TW-22 and 82 mg/L in TW-24.
- The molybdenum concentration in TW-22 is decreasing slowly, similar to TW-37. The 2012 molybdenum concentration in TW-22 is 0.263 mg/L. In TW-24, molybdenum concentrations peaked in 1997 at 1.35 mg/L, and then decreased. A smaller peak of 0.829 mg/L was observed in 2005. Both the 1997 and 2005 peaks were not observed in TW-22 or upgradient source area well TW-37. The 2012 molybdenum concentration in TW-24 is 0.332 mg/L.
- Concentrations of sulfate are stable in TW-22 and TW-24 at less than 250 mg/L following a decrease from historic high concentrations in the 1990's when concentrations of about 750 mg/L were observed (Figure A-8). The peak sulfate concentrations in TW-22 and TW-24 in the 1990's were not observed in source area well TW-37, where sulfate concentrations remained below 500 mg/L.

In LBZ well TW-23, concentrations are either stable or decreasing over the period of record. TW-23 was last sampled in June 2000 (Figures A-9 and A-10).

4.4 TW-26 – UBZ-4

Well TW-26 is completed in UBZ-4 on the west side of the Plant (Figure 2-3).

- Cadmium is generally not detected in TW-26 (Figure A-11).
- Fluoride is increasing in TW-26, with a 2012 concentration of 1.46 mg/L (Figure A-11).
- Manganese is stable at about 0.6 mg/L (Figure A-11).
- Nitrate as N concentrations increased between about 1998 and 2007 to about 6.5 mg/L, and then decreased to a 2012 concentration of 4.28 mg/L as N, but remained below the concentrations observed in the mid-1990's (Figure A-11).
- Selenium concentrations have generally increased since about 1998 (0.13 mg/L), but the 2012 concentration of 0.303 mg/L remains below the concentrations of 0.5 to 0.7 mg/L observed in the mid-1990's (Figure A-12).
- Chloride has decreased since about 1998 when a concentration of 550 mg/L was observed, to 236 mg/L in 2012 (Figure A-12).

- Molybdenum has generally decreased since the early 1990s when concentrations of about 0.2 mg/L were observed, with the exception of a short-term increase in the early 2000s. The 2012 molybdenum concentration is 0.106 mg/L.
- Sulfate concentrations are generally stable in TW-26 at about 300 to 400 mg/L (Figure A-12).

5.0 POTENTIAL SOURCE AREA RELEASE MECHANISMS

5.1 UBZ-2 - Old Underflow Solids Ponds

The Old UFS Ponds are a known source of constituents of concern for groundwater (Golder 1985, 1992a, 1995). When the ponds were closed, the remaining underflow solids were excavated, however, about 35,000 tons of underflow solids remained in the ponds when they were closed (Golder 1992a). The ponds were filled with molten slag and capped with a bentonite cap. The remaining underflow solids are above the water table and below the cap. There are also secondary minerals precipitated in the vadose zone and groundwater below the ponds. Modeling of the cap indicated the infiltration rate through the cap may be about 0.2 inches per year (Golder 1995). There are also ore beneficiation byproducts stockpiled in UBZ-2 on areas of slag fill near the Old UFS Ponds that may be potential sources of constituents of concern in groundwater.

There are several potential mechanisms for the release of constituents from remnant underflow solids in the Old UFS Ponds and secondary minerals precipitated in the vadose zone underlying the Old UFS Ponds, and from materials stockpiled over UBZ-2. The release mechanisms are:

- Groundwater dissolution of precipitated secondary minerals in the vadose zone following an increase in the groundwater elevation associated with spring recharge.
- Infiltration of precipitation and runoff, or ponded snowmelt, and mobilization of constituents from remnant underflow solids or secondary minerals in the vadose zone.
- Disturbance of the cap overlying the Old UFS Ponds during regrading or construction allowing increased infiltration.
- Infiltration of precipitation through material stockpiles.

Each of these potential mechanisms is described in the following sections.

5.1.1 Dissolution by Groundwater

Groundwater elevations for background well TW-57 and the Old UFS Ponds wells (TW-37 and TW-45) are shown in Figure B-1. Figure B-1 also includes groundwater elevations at TW-26 in UBZ-4. Groundwater elevations in wells TW-22, TW-23, and TW-24 are shown in Figure B-2. Figures B-1 and B-2 also include water year (October 1 through September 30, inclusive) precipitation. Review of the figures indicates:

- Groundwater elevations were highest in the mid and late 1990's and in 2009 and 2011. The mid and late 1990's were a period of above-normal precipitation, with a cumulative departure from average water year precipitation since 1990 reaching about 9.5 inches in 1999. The cumulative departure from average water year precipitation then declined and was about -3 to -5 inches between 2003 and 2006, and then about -5 to -10 inches between 2007 and 2011 (Figures B-3 and B-4). 2009 and 2011 were also years of above-average precipitation, however, the cumulative departure from average water year precipitation in both of those years was less than 5 inches.

- There appears to be an overall increase in groundwater elevations of about 2 to 3 feet in TW-57, TW-37, TW-45, TW-23, and TW-24 since about 2003, in spite of average or below-average precipitation and a declining cumulative departure from average water year precipitation since about 1999. This is also observed in other wells across the site (see Appendix I in Golder 2012a). The reason(s) for this increase in groundwater elevations are not known. It may be related to changes in groundwater pumping in the vicinity of the Monsanto Plant or changes in the operation and stage of Blackfoot Reservoir, which supplies recharge to the Blackfoot Lava Field (Dion, 1974, Golder 1995). The stage of the Blackfoot Reservoir varied between about 6,119 and 6,124 feet between May 2011 and November 2011 (U.S. Geological Survey 2012).
- There are short-term increases in groundwater elevation associated with years of above-average precipitation, such as during 2009 and 2011.

The highest groundwater elevation in TW-37 was 5,893.78 feet msl in May 2011. The floor elevation of the Old UFS Ponds when they were in operation is not known. Review of the 1970 topographic map indicates the southern pond was excavated to an elevation of at least 5,936 feet msl (Figure 3-2). This is about 42 feet above the highest observed groundwater elevation (May 2011). Therefore, it is unlikely that the groundwater elevation reached the base of the ponds while the ponds were in operation or since closure.

The short-term increase in groundwater elevations associated with above-average precipitation, such as in 2009 and 2011, and the increasing groundwater elevations observed since about 2003, could result in dissolution of secondary minerals such as otavite and fluorite in the vadose zone below the base of the Old UFS Ponds as the groundwater elevation rises though historically unsaturated materials.

5.1.2 Infiltration of Precipitation

Infiltration of precipitation through the materials capping the Old UFS ponds (crushed slag, bentonite cap, and molten slag fill) could mobilize constituents from remnant underflow solids in the Old UFS ponds. Infiltration of precipitation in areas around the Old UFS Ponds footprint could result in dissolution of secondary minerals in the vadose zone. Figure 5-1 and 5-2 show the relationship between water year precipitation and concentrations of cadmium, chloride, and selenium in TW-37 and TW-22 and TW-24, respectively. Figures 5-3 and 5-4 show the concentrations of the same constituents in TW-37 and TW-22 and TW-24, respectively, and the cumulative departure from average water year precipitation.

- In TW-37, there does not seem to be a relationship between precipitation and cadmium concentration until about 2009. Between about 1994 and 2004 cadmium concentrations are relatively stable, while the cumulative departure from average water year precipitation increases through 1999, then generally decreases through 2008. In 2009 and 2011, cadmium concentrations show a short-term increase coincident with increased precipitation, while in 2009 and 2012, cadmium concentrations show a sharp decrease, coincident with decreased precipitation (Figure 5-1). Chloride concentrations show similar trends. The observed increase in cadmium concentrations is likely related to the coincident increase in chloride concentrations. Infiltration of precipitation likely mobilizes remnant magnesium chloride dust suppressant materials in the soils around the Old UFS Ponds, resulting in increased chloride concentrations in the infiltrating water and dissolution of otavite, and increased cadmium concentrations as cadmium chloride complexes in groundwater (Golder 2011b).

- In TW-22 and TW-24, there appears to be a relationship between molybdenum concentrations and precipitation, particularly during periods of increased precipitation such as between 1995 and 2000 and in 2005 and 2006. Chloride concentrations in 2005 and 2006, 2009, and 2011 also appear to increase with increased precipitation.

  Selenium concentrations in TW-37 do not appear to be correlated with annual precipitation.

5.1.3 Infiltration of Seasonally Ponded Water on West Side of Plant

Monsanto has observed ponded water in a closed depression on the west side of the Plant and along Threemile Knoll Road between the west Plant gate and the surface expression of the Monsanto Fault (Figure 3-7) during periods of rapid snowmelt, such as during March 2012. This area is in the southwest, or downthrown, side of the Monsanto Fault. The water depths are estimated to be about 6 to 8 feet at the deepest point, or a water surface elevation of about 5,950 feet. The snowmelt likely originates from snow on the agricultural lands west of the Monsanto Fault (Figure 3-7). In addition, Monsanto also stockpiles snow from the site roads on an area filled with crushed slag north of the Old UFS Ponds that could contribute to the ponded water.

The estimated ponded water surface elevation in March 2012 of about 5,950 feet msl was higher than the groundwater elevation of 5,944 feet msl in nearby well TW-57 in May 2011 and higher than the May 2011 groundwater elevation of 5,893 feet msl in TW-37. Based on observations by Monsanto, this ponded water infiltrates relatively quickly (over the course of several days). The final depths of the Old UFS Ponds are not known. The base of the southern pond was at least 5,936 feet msl in 1970, or about 14 feet below the 2012 ponded water surface elevation. In 1970, the northern pond was being used for slurry dewatering, and had a water surface elevation of 5,961 feet msl, or about 11 feet higher than the 2012 ponded water surface elevation. It is possible that the ponded water may infiltrate through either remnant pond materials or secondary minerals precipitated below the pond bases. The ponded water also comes in contact with crushed slag that was used to fill the area of the Old UFS Ponds. The ponded water may also come into contact with materials in the unidentified disposal area depending on the elevation of this potential source.

5.1.4 Topographic Changes in Old UFS Ponds Area

The Old UFS Ponds were closed by removing most of the remaining underflow solids, filling the pond with molten slag, and capping the ponds with a bentonite cap. There are no as-builts or construction details for the closure of the ponds. Based on comparison of the 1970, 1991, and 2011 topographic profiles in the pond area (Figures 3-8 and 3-9), the area in the vicinity of the Old UFS Ponds has been filled with crushed slag, increasing the ground elevation above the cap. Thus, it is unlikely that there have been changes in topography that could have affected the closure of the Old UFS Ponds.

5.2 UBZ-2 - Materials Stockpiles

There are ore beneficiation byproducts and other materials stockpiled in UBZ-2 on areas of slag fill near the Old UFS Ponds that may be potential sources of contamination. These materials include:

- Crushed slag was used for fill and stockpiled for general use at the Plant. The laydown areas in UBZ-2 are all on crushed slag fill.
- Quartz sand (fine quartzite) and basalt cinders used for general use at the Plant and as traction material in the winter.
- Treater dust is fine-grained material separated by electrostatic precipitators as phosphorus gas is condensed to a liquid.
- Nodules fines piles are fine nodules resulting from the nodulizing of the phosphate ore in the kiln.

Monsanto also stockpiles snow removed from Plant roads on the north end of the crushed slag fill. The locations of the stockpiled materials are shown in Figure 3-6.

The slag is not considered to be a potential source of constituents of concern in groundwater (Golder 1995). The slag passed TCLP testing (Table 3-4). Quartzite sand and basalt cinders are also not considered sources of constituents of concern in groundwater. The quartzite was characterized (Golder 1995) and found to have very low concentrations of cadmium (0.026 mg/kg; Table 3-2) and less than 0.2 mg/kg selenium.

Treater dust was characterized as part of the RI activities (Tables 3-2 and 3-4). The treater dust passed TCLP testing (Table 3-4). Nodules were characterized as part of the RI activities (Table 3-2) and by Monsanto (Table 3-3). The nodules have low concentrations of cadmium (less than 2 to about 11 mg/kg) and selenium (1.6 to 14 mg/kg). Nodules and treater dust have high fluoride (about 87,000 to 102,000 mg/kg and 22,000 to 25,000 mg/kg, respectively) based on Monsanto characterization (Table 3-3).

Based on the materials classification completed as part of the RI and by Monsanto, the crushed slag, quartzite, and basalt cinders are not considered to be sources of constituents of concern for groundwater.

5.3 UBZ-4 Source Areas

Source areas within the UBZ-4 could affect groundwater quality in the UBZ-2 if there is groundwater flow from the UBZ-4 source areas to the UBZ-2. Based on the information available, there appears to be little groundwater flow, if any, from the UBZ-4 to the UBZ-2. The information used to make this evaluation includes:

- Groundwater elevations on either side of the Monsanto Fault
- Observations of groundwater elevation changes in wells on either side of the Monsanto Fault in response to pumping the plant production wells

The UBZ-4 is separated from the UBZ-2 by the Monsanto Fault, a hinge fault. In the area to the east of the Old UFS Ponds, the Monsanto Fault is inferred to be a hydraulic barrier because there is a groundwater elevation difference of about 15 feet between wells TW-26 and TW-37 and about 20 to 25 feet between TW-26 and wells TW-22 and TW-24 (Figure 5-5). In addition, the effects of plant well pumping are not observed on the west side of the Monsanto Fault.

Monsanto pumps PW-03 continuously to supply non-contact cooling water for the furnaces. When additional water is needed, a second well (either PW-01 or PW-02) is cycled on to provide water. Typically the additional well is operated for only a few minutes and then shuts down. Wells TW-22, TW-24, and TW-37 located west of the Monsanto Fault are not affected by the short-term cyclical pumping of a second production well (Figures 5-6a and 5-6b). TW-26 has short-term (on the order of 6 to 10 hour) approximately sinusoidal groundwater level fluctuations that were correlated to earth tides (Golder 1985). These fluctuations are not observed in TW-22 and TW-24 (Figure 5-6a) but appear to be occurring in TW-37 (Figure 5-6b).

There may be some groundwater flow across the fault from the UBZ-4 to UBZ-2 because of the groundwater elevation difference across the Monsanto Fault. Concentrations of selenium in TW-26 have been increasing since about 2000 (Figure A-12) and have been slightly higher than selenium concentrations in TW-37 since about 2009. Selenium concentrations in TW-16 (Northwest Pond area) have been increasing since 2007, but remain below selenium concentrations in TW-37 (Golder 2012a). The Monsanto Fault thus appears to be a low-permeability barrier to groundwater flow; any groundwater flow across the fault as a result of the difference in groundwater elevation is thus very small

6.0 UBZ-2 SOURCE AREAS PRELIMINARY CONCEPTUAL MODEL

This section describes the preliminary conceptual model for the UBZ-2 source areas. The conceptual model is summarized in Table 6-1. Investigations described in Section 7 will be used to confirm the conceptual model.

6.1 Hydrogeology

The geologic units in the UBZ-2 consist of a series of low-permeability basalt flows and interbedded, higher permeability interflow zones consisting of cinders, rubbly basalt, and sedimentary materials. There is some vertical hydraulic communication between interflow zones particularly within the UBZ. The basalt is overlain by unconsolidated sediments and fill materials.

Two faults border UBZ-2, the Monsanto Fault on the east side and the Subsidiary Fault of the west side. The Monsanto Fault appears to act as a hydraulic barrier in Plant area near the Old UFS Ponds based on groundwater levels and response to pumping of the Plant Production Wells. The Subsidiary Fault appears to act as a partial barrier to groundwater flow south and west of the Old UFS Ponds, allowing some flow of groundwater from UBZ-2 to UBZ-1 based on groundwater quality data.

The hydraulic conductivity of UBZ-2 is locally highly variable depending on the thickness of the interflow zones and the type of materials in the interflow zones. The hydraulic conductivity is estimated to range from about 1 to 1,000 ft/d. The groundwater velocity is estimated to range from about 1 to 2 ft/d. The hydraulic conductivity in UBZ-2 was estimated to range from about 33 to 220 ft/d based on the groundwater velocity and an assumed effective porosity of 30%.

Groundwater elevations in areas of UBZ-2, including wells near the Old UFS Ponds, appear to have increased about 2 to 3 feet since about 2003 despite near-average precipitation. Groundwater levels also respond over the short-term in response to changes in precipitation. Groundwater flow in UBZ-2 is to the southeast in the Plant area and to the south in the area south of the South Plant Fence Fine. There is a downward component of vertical hydraulic gradient near the Old UFS Ponds. At the South Plant Fence Line in the UBZ-2, there is a downward component of vertical hydraulic gradient.

6.2 Source Areas

The primary source area in UBZ-2 is remnant materials remaining in the Old UFS Ponds following closure and secondary minerals precipitated in the vadose zone below the ponds. The Old UFS Ponds were unlined ponds used to dewater underflow solids. The ponds were closed in 1987 by excavating most of the remaining underflow solids and filling the ponds with molten slag. The ponds were then capped with bentonite and crushed slag. About 35,000 tons of materials remained in the ponds following closure.

These remnant materials appear to be above the water table based on the estimated pond depths and groundwater elevations in nearby wells.

There is a former "tailings" pond located south of the Old UFS Ponds and north of the coke and quartzite ponds (Figure 3-2) that appears to be a potential source area. There is no information on the closure of this pond however it appears to be out of service by 1970.

There are some material stockpiles in UBZ-2 including crushed slag, slag placed as molten material, sand, cinders, and clean soils.. These materials are not significant sources of groundwater contamination because of the low concentrations of constituents of concern. Treater dust and nodules are also stockpiled in UBZ-2. These materials may be potential sources of fluoride based on the geochemical characterization.

There are also former source areas in UBZ-1 and UBZ-4. The UBZ-1 source areas including the former coke and quartzite ponds, former effluent setting pond, and former sewage evaporation ponds, are all downgradient of the UBZ-2 source areas and were all closed in the late 1980s and early 1990s. Slag stockpiles in UBZ-1, either crushed or material originally placed as molten slag, is not a potential source of groundwater contamination.

While there are documented sources of contamination in the UBZ-4, affected groundwater is captured by the Plant Production wells. Any groundwater flow from source areas in the UBZ-4 to the UBZ-2 would be very minor because of the hydraulic barrier created by the Monsanto Fault

6.3 Constituent Release Mechanisms

There are several potential mechanisms for release of constituents from former source areas to UBZ-2 groundwater, or for migration of constituents from other areas of the Plant to UBZ-2:

- Infiltration of precipitation and mobilization of constituents from remnant materials in the Old UFS Ponds and the "tailings" pond, and mobilization of constituents from secondary minerals precipitated in the vadose zone below the source areas. Periods of above-average precipitation may result in greater mobilization of selected constituents.
- Dissolution of secondary minerals (such as otavite) precipitated in the vadose zone may occur by increases in groundwater elevation as formerly unsaturated materials are re-saturated.
- Increase in otavite solubility under the effects of increased chloride in infiltration water. The chloride is the result of the use of magnesium chloride as a dust suppressant agent on the Plant roads. Otavite has increased solubility in the presence of chloride and thus cadmium is released to groundwater from the secondary source in the vadose zone.

Disruption of the bentonite cap causing increased infiltration into the Old UFS Ponds is considered unlikely because most of the area of the Old UFS Ponds has been filled with crushed slag.

6.4 Conceptual Model Uncertainties

There are several uncertainties in the conceptual model for the UBZ-2 source areas. The uncertainties include:

- The quality of infiltrating water after contact with the remnant old underflow solids and the groundwater quality below each pond.
- The groundwater quality at the downgradient edge of the Old UFS Ponds and downgradient of the former coke and quartzite dust slurry ponds. This is because the existing UBZ monitoring well at the Old UFS ponds (TW-37) is located near the middle and to the west of the southern pond. This information is required to better understand the total concentration and loading of constituents of concern to the UBZ-2 from the Old UFS Ponds.
- The geochemical nature and extent of the “tailings” in proximity to TW-22, TW-23 and TW-24 and presence or absence of cover materials to minimize infiltration.

7.0 RECOMMENDATIONS

The following are recommendations to address the uncertainties in the source area conceptual model.

7.1 Old UFS Ponds – UBZ-2

The following are recommended to characterize the Old UFS Ponds in UBZ-2:

- Drilling of two boreholes, one near the center each of Old UFS Ponds in order characterize the geologic and hydrogeologic conditions in the pond areas, to collect samples for geochemical characterization, and install monitoring wells to characterize groundwater quality below the ponds.
  - The boreholes should be drilled using either air-rotary drilling methods with an under-reaming or dual-rotary casing advancement system or sonic drilling methods in order to collect representative samples of the potential source and geologic materials.
  - Samples should be collected at 5-foot intervals for geologic and geochemical characterization.
  - The boreholes should be drilled at 8-inch diameter in order to install 4-inch diameter monitoring wells. The boreholes should be drilled through the first water-bearing interflow zone below the ponds and a well installed in the first water-bearing interflow zone below the ponds.
- The geochemical characterization of the soils and geologic materials, remnant source materials and vadose zone materials collected in the boreholes will follow a phased approach. The geochemical characterization will include the following:
  - **Elemental analysis** - Characterization of the elemental composition of a sample is typically a two-step process that includes an acid digestion to release elements into the solution phase followed by analysis of the elements in the resulting digestion. Metals analysis will be conducted following USEPA Method 3050b. Leachates will be analyzed for the constituents listed in Table 7-1.
  - **Leach Testing** – Leach testing will be conducted following standard USEPA protocols (i.e. SPLP). A site specific methodology will also be developed to evaluate leaching following interaction of vadose zone solids with site groundwater and site groundwater with elevated chloride concentrations. Leach test methods are listed below. The analytical suites for leachates are listed in Table 7-1.
    - **Synthetic Precipitation Leaching Procedure (SPLP)** – The SPLP leach test (USEPA Method 1312) (USEPA 1994) simulates the short-term interaction between meteoric water and a solid. This test is performed at a 20:1 solution to solid ratio. SPLP testing for this study will be conducted at a 4:1 solution to solid ratio to be more representative of the solution to solid ratio under site conditions.
    - **Groundwater Leach Test** – Leach testing will be conducted using site groundwater and site groundwater spiked with magnesium chloride ($MgCl$). Testing will be conducted at a 4:1 solution to solid ratio for 18-hours (i.e. similar to the SPLP test methodology).
  - **Mineralogical Analysis** – In addition to characterization of the forms in which the COCs occur in source materials, mineralogical analysis will be performed on vadose zone samples to confirm the presence, or absence, of secondary mineral phases (i.e. otavite, rhodochrosite and fluorite). Mineralogical analysis methods will be selected

based on the type of sample and may include X-ray diffraction (XRD) analysis or scanning electron microprobe (SEM) analysis.

- As indicated above, a phased approach will be followed for the selection and analysis of samples for geochemical characterization. Elemental analysis will be performed on samples collected along a vertical profile through the source area and underlying vadose zone. Based on the results of elemental analysis, samples will be selected for leach testing and mineralogical analysis.
- Drill and install one monitoring well downgradient of the southern Old UFS Pond to provide information on groundwater quality immediately downgradient of the Old UFS Ponds.
  - The borehole should be drilled using either air-rotary drilling methods with an under-reaming or dual-rotary casing advancement system or sonic drilling methods in order to collect representative samples of the potential source and geologic materials.
  - Samples should be collected at 5-foot intervals for geologic characterization and, if potential unanticipated materials are encountered, geochemical characterization.
  - The borehole should be drilled at 8-inch diameter in order to install 4-inch diameter monitoring wells. The boreholes should be drilled through the first water-bearing interflow zone below the ponds and a well installed in the first water-bearing interflow zone below the ponds.

The recommended borehole locations are shown in Figure 7-1, and summarized in Table 7-2.

7.2 Unidentified Disposal Area – UBZ-2

The following are recommended to characterize the unidentified disposal area in UBZ-2:

- Drilling of one borehole near the center of the inferred area of the unidentified disposal area in order characterize the geologic and hydrogeologic conditions in the disposal area, to collect samples for geochemical characterization, and install a monitoring well to characterize groundwater quality below the ponds.
  - The borehole should be drilled using either air-rotary drilling methods with an under-reaming or dual-rotary casing advancement system or sonic drilling methods in order to collect representative samples of the potential source and geologic materials.
  - Samples should be collected at 5-foot intervals for geologic and geochemical characterization.
  - The borehole should be drilled at 8-inch diameter in order to install 4-inch diameter monitoring wells. The boreholes should be drilled through the first water-bearing interflow zone below the ponds and a well installed in the first water-bearing interflow zone below the ponds.
- The geochemical characterization of the soils and geologic materials, any remnant source materials and vadose zone materials collected in the borehole will be completed in a similar phased manner to the Old UFS Ponds characterization.

The recommended borehole location is shown in Figure 7-1, and summarized in Table 7-2.

7.3 "Tailings" Pond – UBZ-2

The following are recommended to characterize the "tailings" pond in UBZ-2:

- Excavation of 6 to 8 test pits to depths of about 20 feet to characterize the areal extent of the pond. The test pit locations are shown in Figure 7-1, and approximate coordinates are summarized in Table 7-2. The test pit locations are tentative and may need to be adjusted depending on the thickness of crushed slag fill at the proposed location and limitations of the equipment used for excavation. Samples will be collected from potential source materials and geochemically characterized using SPLP testing and whole rock analyses (Table 7-1).
- Drilling of two boreholes in order characterize the geologic and hydrogeologic conditions in the pond areas, to collect samples for geochemical characterization, and install monitoring wells to characterize groundwater quality below the pond.
  - The boreholes should be drilled using either air-rotary drilling methods with an under-reaming or dual-rotary casing advancement system or sonic drilling methods in order to collect representative samples of the potential source and geologic materials.
  - Samples should be collected at 5-foot intervals for geologic and geochemical characterization.
  - The boreholes should be drilled at 8-inch diameter in order to install 4-inch diameter monitoring wells. The boreholes should be drilled through the first water-bearing interflow zone below the pond and a well installed in the first water-bearing interflow zone below the pond.
- The geochemical characterization of the soils and geologic materials, any remnant source materials and vadose zone materials collected in the borehole will be completed in a similar phased manner to the Old UFS Ponds characterization.

The recommended borehole location is shown in Figure 7-1. The test pit and borehole locations are shown in Figure 7-1, and summarized in Table 7-2. The borehole locations are tentative and will be confirmed following completion of the test pits.

8.0 CLOSING

Please contact us if you have any questions or need additional information.

GOLDER ASSOCIATES INC.

Michael Klisch
Senior Project Hydrogeologist

David Banton
Principal Hydrogeologist

MK/DB/kd

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TABLES

Table 2-1: Soda Springs Climate Summary

Water Year	Soda Springs Airport[1]		Somsen Ranch Sno-Tel[2]		Slug Creek Divide Sno-Tel[3]	
	Water Year Precipitation (inches)	Water Year Snowfall (inches)	Water Year Precipitation (inches)	Water Year Snow Water Equivalent (inches)	Water Year Precipitation (inches)	Water Year Snow Water Equivalent (inches)
1980	16.19	41.0	na	na	na	na
1981	15.65	31.8	20.80	8.70	23.80	13.30
1982	20.81	34.0	38.90	22.60	49.80	32.10
1983	18.29	41.7	31.30	15.90	37.50	21.50
1984	22.03	61.2	32.40	17.80	39.30	23.60
1985	14.51	73.5	24.60	16.30	29.70	17.80
1986	na	na	37.20	18.80	46.80	27.60
1987	12.73	23.3	17.10	7.90	21.50	9.30
1988	8.85	23.4	16.30	9.70	21.30	13.40
1989	14.17	71.7	24.60	13.80	27.60	17.10
1990	13.45	39.5	21.40	9.50	24.50	10.50
1991	17.01	35.0	28.70	12.60	33.50	12.70
1992	9.48	25.0	16.50	6.50	21.80	7.80
1993	21.75	29.0	34.30	15.20	38.90	16.30
1994	13.30	37.0	18.40	10.10	22.40	13.70
1995	17.33	46.0	31.70	11.80	38.20	14.40
1996	15.09	58.0	28.40	15.90	37.20	20.40
1997	21.91	45.1	38.80	19.80	47.20	24.90
1998	13.57	44.9	26.10	13.40	34.60	16.10
1999	18.67	65.0	28.80	14.60	33.30	17.30
2000	10.90	34.0	20.70	13.60	24.10	13.90
2001	9.34	43.0	19.00	7.50	20.10	7.90
2002	15.00	38.0	24.00	11.90	26.60	12.70
2003	11.27	48.1	21.20	11.10	27.50	14.10
2004	14.80	41.0	29.60	12.90	31.60	13.40
2005	16.92	63.0	24.40	11.40	33.30	13.60
2006	15.82	79.5	28.80	15.50	35.40	20.20
2007	10.98	39.0	23.10	10.10	27.50	12.10
2008	13.27	8.0	26.10	14.10	32.20	20.10
2009	19.38	57.9	33.20	14.00	40.30	18.10
2010	12.63	41.0	23.90	10.00	28.20	13.20
2011	18.07	73.0	34.50	15.00	44.70	24.50
2012	na	17.0	na	na	na	na
Minimum	8.85	8.00	16.30	6.50	20.10	7.80
Maximum	22.03	79.50	38.90	22.60	49.80	32.10
Average	15.26	44.02	26.61	13.16	32.27	16.57

Notes
1. Data from http://cdo.ncdc.noaa.gov/dlyp/DLYP.
2. Data from http://www.wcc.nrcs.usda.gov/nwcc/site?sitenum=770&state=id
3. Data from http://www.wcc.nrcs.usda.gov/nwcc/site?sitenum=761&state=id
na: not available
Shaded = above average precipitation or snowfall/SWE

Table 2-2: UBZ-2 Hydrualic Conductivity Summary

Well Number	Location	Basalt Flow or Interflow Zone	Test Type	Hydraulic Conductivity (feet/day)	Analysis Method	Reference
TW-6	UBZ-2	Gamma 3	Short-Term Pumping	394	Jacob	Golder 1985
			Recovery	440	Theis Recovery	
TW-34	UBZ-2	Gamma 3	Falling Head	0.3	Hvorslev	Golder 1985
TW-54	UBZ-2	Gamma 4	Slug Removal	2.2	Hvorslev	Golder 1995
			Recovery	5.5	Theis Recovery (30 sec pump	
			Recovery	8.6	Theis Recovery (45 sec pump	
TW-55	UBZ-2	Gamma 3	Short-Term Pumping	379	Jacob	Golder 1995
			Recovery	516	Theis Recovery	
TW-57	UBZ-2	Gamma 5	Short-Term Pumping	341	Jacob	Golder 1995
			Recovery	676	Theis Recovery	
TW-58	UBZ-2	Gamma 4	Step Pumping	5,628	Eden-Hazel	Golder 1995
			Step Pumping	7,808	Jacob - First Step	
			Step Test Recovery	4,285	Theis Recovery	
			Recovery	104	Theis Recovery	
TW-59	UBZ-2	Gamma 4	Falling Head	8.2	Hvorslev	Golder 2007
			Falling Head	7.9		
TW-62	UBZ-2	Gamma 4	Falling Head	35.6	Hvorslev	Golder 2007
			Falling Head	45.8		
			Falling Head	40		
TW-63	UBZ-2	Gamma 5	Rising Head	10.7	Hvorslev	Golder 2012b
			Rising Head	12.3		
			Falling Head	11.6	Hvorslev	Golder 2012b
			Falling Head	13.4		
TW-64	UBZ-2	Gamma 5	Rising Head	68.6	Hvorslev	Golder 2012b
			Rising Head	67.8		
			Falling Head	51.7	Hvorslev	Golder 2012b
			Falling Head	52.4		
TW-65	UBZ-2	Gamma 5	Rising Head	9.6	Hvorslev	Golder 2012b
			Falling Head	7.9		
TW-66	UBZ-2	Gamma 4	Rising Head	0.91	Hvorslev	Golder 2012b
			Falling Head	1.74		
TW-67	UBZ-2	Gamma 4	Short-Term Pumping	579	Cooper-Jacob	Golder 2012b
			Recovery	947	Theis Recovery	
TW-70	UBZ-2	Gamma 3	Short-Term Pumping	421	Cooper-Jacob	Golder 2012b
			Recovery	253	Theis Recovery	

Table 2-3: Vertical Component of Hydraulic Gradient - May 2011

Location	Interflow Zones	Wells	Component of	Direction	Note
UBZ-1	γ4 - γ5	TW-07/TW-10	0.006	Upward	Southwest Corner of Plant
	γ3 - γ5	TW-08/TW-10	0.006	Upward	
	LBZγ2 - γ5	TW-09/TW-10	0.038	Upward	
UBZ-2	LBZγ2 - γ4	TW-45/TW-37	-0.037	Downward	Near Old USF Ponds
	LBZγ2 - γ4?	TW-23/TW-22	0.015	Upward	Between Old UFS Ponds and Former Coke/Quartzite Ponds
	LBZγ2 - γ4	TW-23/TW-24	0.011	Upward	
	γ3 - γ4	TW-35/TW-39	0.006	Upward	Plant South Fenceline
	LBZγ2 - Flow V	TW-21/TW-19	0.008	Upward	Plant South Fenceline
	LBZγ2 - γ4	TW-21/TW-20	0.006	Upward	Plant South Fenceline
	LBZγ2 - γ3	TW-21/TW-34	0.002	Upward	Plant South Fenceline
UBZ-4	LBZγ2 - γ3	TW-18/TW-16	0.006	Upward	Northwest Pond
	LBZγ2 - γ3	TW-18/TW-17	0.010	Upward	

Table 2-4: Estimated Groundwater Velocity

Well Pair	Distance (feet)	Peak Concentration in Upgradient Well	Peak Concentration in Downgradient Well	Estimated Groundwater Velocity (ft/d)	Estimated Hydraulic Conductivity (ft/d)
Nitrate					
TW-37/TW-22	4,059	1985	1994	1.2	59
TW-37/Calf Spring	4,786	1985	1995	1.3	62
TW-22/TW-20	2,733	1998	2006	0.9	45
TW-22/TW-54	3,501	1998	2006	1.2	57
			Geometric Mean	1.2	55
Chloride					
TW-37/TW-20	4,059	1985	1992	1.6	76
TW-22/TW-20	2,733	1999	2005	1.2	59
			Geometric Mean	1.4	67
Selenium					
TW-37/TW-22	4,059	1994	1999	2.0	96
TW-22/TW-20	2,733	1999	2005	1.2	59
TW-20/Mormon A Spring *(UBZ-1)*	1,694	2005	2006	4.6	220
			Geometric Mean	2.3	108
Sulfate					
TW-22/Calf Spring	3,371	1985	1994	1.0	49
TW-22/TW-20	2,733	1998	2006	0.9	44
TW-22/TW-54	3,501	1998	2006	1.2	56
TW-22/TW-54	3,501	1985	1995	0.9	44
			Geometric Mean	1.0	48
Molybdenum					
TW-12/Lewis *(UBZ-3)*	3,075	1993	1997	2.1	100
TW-20/TW-54	1,000	1994	1996	1.4	65
TW-20/Harris	1,076	1994	1997	1.0	47
TW-20/Mormon A Spring *(UBZ-1)*	1,694	1994	1997	1.5	73
TW-24/TW-20	2,733	1997	2006	0.8	39
			Geometric Mean (excludes UBZ-3)	1.1	54
			Geometric Mean (all constituents in UBZ-2)	1.3	61

Notes:
Assumes overall hydraulic gradient = 0.0063 (based on 2007 groundwater elevation date - TW-37 to TW-54
Assumed effective porosity = 30%
All wells in UBZ-2 except as noted

Table 3-1: Source Area Map and Aerial Photography Chronology

Year	Image	Coke/Quartzite Ponds (UBZ-1/UBZ-2)	Effluent Settling Pond (UBZ-1/UBZ-2)	Sewage Evaporation Ponds (UBZ-1)	"Tailings" Pond (UBZ-2)	Old Underflow Solids Ponds (UBZ-2)	Old Underflow Solids Ponds (UBZ-4)	Old Hydroclarifier (UBZ-4)	Northwest Pond (UBZ-4)	Other Observations
1970	Topographic map from air photo (10/15/1970)	3(?) ponds separated by berm, no standing water. Northern pond floor elevation ~ 5,948 feet, middle pond floor elevation ~ 5,939 feet, southern pond floor elevation ~ 5,915 feet. Noted as Tailings Ponds on map	One ~ 200-foot diameter pond with a water elevation of 5,921 feet. Ditch from pond clearly seen. Second smaller pond (~75 foot diameter) observed southeast of larger pond.	Not Observed	No water noted, eastern part may be covered with crushed slag fill about 40 feet thick - equipment laydown/storage on top of slag fill.	Northern pond standing water elevation 5,961 feet, southern pond no water, excavations to elevation 5,936 feet	Seven narrow ponds shown on map. Three shown with water at elevations of 5,990.5, 5983.0, and 5,985.2 feet. One pond appears to be partially excavated.	Shown on topography	Standing water in south end of pond, elevation 5,965 feet.	UBZ-2 - area north of Old UFS ponds not filled, ground elevation 5,939 feet. UBZ-2 - Dam and pond on south end of slag pile, pond base elevation 5,870 feet.
1974	Air Photo (hand labeled with date)	2 ponds, middle pond from 1970 map appears to have slurry a passing through, southern pond appears have slurry and standing water on south end. Northernmost "tailings pond" noted on 1970 map appears to be filled with slag.	One ~ 200-foot diameter pond with a water elevation of 5,921 feet. Ditch from pond visible. Second smaller pond (~75 foot diameter) observed southeast of larger pond.	Not Observed	Pond area appears to be covered with crushed slag.	Northern pond active, standing water visible, southern pond being excavated. Possible seepage from north side of northern pond - dark area north of pond.	Seven narrow ponds shown on photo. All appear to have some water.	Visible on photo, appears to be full of water	Standing water in south end of pond	UBZ-2 - area north of Old UFS ponds not filled UBZ-2 - Dam or berm and pond on south end of slag pile, water behind dam
1985	Air Photo	2 ponds, middle pond from 1970 map appears to be active and mostly filled with dark material - coke(?), southern pond appears to be overflow (?) and not active - vegetation observed on surface, with some standing water apparent. Northernmost "tailings pond" noted on 1970 map appears to be filled with slag.	200-foot diameter pond appears to be water filled, smaller pond to southeast dry	2 Ponds, both appear to be water filled	Pond area appears to be covered with crushed slag.	Appears to be excavation activity in both ponds, no standing water.	Ponds no longer visible. Pond area used for storage of what appears to be nodules and treater dust	Visible on photo, appears to be full of water	No water noted on photo	UBZ-2 - area north of Old UFS ponds not filled, appears to have some ponded water UBZ-2 - Dam and pond on south end of slag pile not visible. Areas of linear green vegetation visible UBZ-3 - Hydroclarifier appears to be Old Hydroclarifier - water visible
1991	Topographic map (AutoCAD format)	Southern pond floor elevation 5,919 feet	One ~ 200-foot diameter pond with a water elevation of 5,922.4 feet.	2 ponds present, water surface 5,903.4 feet in northern pond, water surface 5,896.7 feet in southern pond	No pond shown	Appear to be filled and partially covered with crushed slag	Ponds no longer visible. Pond area has materials stockpiled.	Hydroclarifier on map - New hydroclarifier	Water surface eelvation in northwest part of pond at 5,969.3 feet	UBZ-2 area north of Old UFS ponds is being filled
1992	Air Photo (Google Earth Image 7/29/1992)	Appear to be filled and grass covered, portions covered with slag	Large pond present, smaller pond covered with molten slag	2 ponds present, appear to be filled with water/effluent	No pond shown, area appears to be covered with crushed slag	Both ponds appear to be filled and grass covered, and partially covered with crushed slag	Ponds no longer visible. Pond area has materials stockpiled.	Hydroclarifier on photo - New hydroclarifier	No water apparent on photo	UBZ-2 area north of Old UFS ponds is being filled Dam and pond observed in 1970 air photo under slag pile
1998	Air Photo (Google Earth Image 7/2/1998)	Appear to be filled and grass covered, portions covered with slag	Large pond appears to be filled and partially covered with slag	Ponds out of service and appear to be filled with molten slag?	Pond area appears to be partly covered with molten slag	Both ponds appear to be filled and grass covered, and partially covered with crushed slag	Ponds no longer visible. Pond area has materials stockpiled.	Hydroclarifier on photo - New hydroclarifier	No water apparent on photo	UBZ-2 area north of Old UFS ponds is being filled
2003	Air Photo - Plant Area	Covered with molten slag	Covered with molten slag	Covered with molten slag	Area covered with molten slag appears to have some of the slag removed	Both ponds covered with crushed slag	Ponds no longer visible. Pond area has materials stockpiled.	Hydroclarifier on photo - New hydroclarifier	No water apparent on photo	
2011	Air Photo - Plant Area	Covered with molten slag	Covered with molten slag	Covered with molten slag	Area covered with crushed slag and some molten slag	Both ponds covered with crushed slag	Ponds no longer visible. Pond area has materials stockpiled.	Hydroclarifier on photo - New hydroclarifier	No water apparent on photo	Area around West Plant Gate regraded as part of new gate construction

Notes:
Old Hydroclarifier replaced in 1985.
Old UFS Ponds in UBZ-2 capped in 1987
Northwest Pond converted to permitted landfill in 1986
Coke and Quartzite Ponds covered with molten slag by 1998
Effluent Settling Pond covered with molten slag by 1998
Sewage Evaporation Ponds covered with molten slag by 1999

Table 3-2: Source Area Materials Geochemical Characterization Data

Material	Size Fraction	Areas Stockpiled	Number of Samples	Average Concentrations				
				Cadmium (mg/kg)	Fluoride (mg/kg)	Manganese (mg/kg)	Selenium (mg/kg)	Molybdenum (mg/kg)
Coke	-200 mesh	UBZ-4	6	<3.8	72 ± 55	14 ± 3.0	1.3 ± 0.81	2.0 ± 1.4
	Total		6	<9.6	5.5 ± 4.3	4.2 ± 0.95	0.39 ± 0.26	0.73 ± 0.41
Old Nodules	-200 mesh	UBZ-2, UBZ-4	3	<7.7	30 ± 8.0	65 ± 16	8.3 ± 2.6	31 ± 8.7
New Nodules	Total	UBZ-2, UBZ-4	3	11 ± 7.1	13 ± 3.1	38 ± 9.7	1.60 ± 0.95	14 ± 3.6
Ore Blend-1	-200 mesh	UBZ-4	6	121 ± 5.7	43 ± 30	76 ± 12	46 ± 23	31 ± 10
	Total		6	120 ± 16	59 ± 7.4	40 ± 4.2	28 ± 9.4	19 ± 9.1
Ore Blend-2	-200 mesh	UBZ-4	3	132 ± 3.0	6.6 ± 1.5	61 ± 15	65 ± 15	30 ± 1.6
	Total		3	132 ± 19	25 ± 18	35 ± 7.8	41 ± 14	12 ± 3.1
Quartzite	Total	UBZ-4	3	0.026 ± 0.031	NM	<9.6	<0.2	<0.86
Baghouse Dust	-200 mesh	UBZ-4	3	211 ± 261	136 ± 98	104 ± 62	0.40 ± 0.17	NM
Old Slag	Total	UBZ-1, UBZ-2	3	15 ± 7.4	50 ± 19	113 ± 39	7.3 ± 1.7	2.3 ± 1.9
New Slag	Total	UBZ-1, UBZ-2	3	21 ± 6.2	51 ± 20	46 ± 2.2	4.0 ± 3.2	1.0 ± 2.54
Coke and Quartzite(?) Slurry Pond	-200 mesh	UBZ-1	3	285 ± 306	215 ± 116	74 ± 6.6	15.1 ± 8.19	NM
Ferrophos Slag	Total	UBZ-4	3	36 ± 4.6	9.4 ± 0.34	846 ± 45	0.37 ± 0.14	860 ± 45
Old Treater Dust	-200 mesh	UBZ-2, UBZ-4	3	131 ± 2.6	288 ± 21	230 ± 21	33 ± 23	2.7 ± 1.5
New Treater Dust	Total	UBZ-2, UBZ-4	3	40 ± 11	8,571 ± 6,191	57 ± 8.6	13 ± 2.2	6.9 ± 0.72
Underflow Solids Piles	-200 mesh	UBZ-3	6	1,313 ± 364	227 ± 167	179 ± 64	208 ± 20	NM
	Total		6	1,197 ± 762	623 ± 102	93 ± 3.9	169 ± 33	36 ± 5.2

Notes:
NM: Not measured
Source: Golder 1992, 1995
For locations see Figure 3-1

Table 3-3: Materials Characterization Data - Data Collected by Monsanto March 2006

Material	Areas Stockpiled	Cadmium (mg/kg)	Fluoride (mg/kg)	Manganese (mg/kg)	Selenium (mg/kg)	Molybdenum (mg/kg)
		Method 6010B	Method 4500-F-C	Method 6010B	Method 6010B	Method 6010B
Treater Dust	UBZ-2/UBZ-4	122	22,300	34	<10	8
		126	23,300	33	11	8
		127	25,500	34	<10	9
Scale Room Bag House	UBZ-4	2	20,000	24	<10	13
		2	16,900	22	<10	12
		2	18,800	23	<10	12
Coke Handling Bag House	UBZ-4	<2	20	14	<10	<5
		<2	30	13	<10	<5
		<2	20	16	<10	<5
Sweetwater Coke	UBZ-4	<2	<10	4	<10	<5
		<2	<10	4	<10	<5
		<2	<10	4	<10	<5
Nodule Reclaim Bag House	UBZ-4	4	26,600	26	56	19
		3	23,300	24	56	18
		3	26,200	23	59	18
Dryer Bag House	UBZ-4	3	41	12	<10	<5
		3	47	12	<10	<5
		3	48	12	<10	<5
Collier Coke	UBZ-4	<2	<10	<2	<10	6
		<2	<10	<2	<10	5
		<2	<10	<2	<10	7
Main Bag House	UBZ-4	<2	14,500	21	<10	10
		<2	13,400	20	<10	10
		<2	15,000	19	<10	10
IOS Bag House	UBZ-4	<2	13	15	<10	<5
		<2	12	15	<10	<5
		<2	10	15	<10	<5
Quartzite	UBZ-2/UBZ-4	<2	22	15	<10	<5
		<2	27	14	<10	<5
		<2	27	13	<10	<5
Ferro Phos Slag	UBZ-4	<10	129	570	130	534
		<10	125	588	130	553
		<10	121	549	130	521
Ore Blend 1	UBZ-4	150	69,900	42	30	20
		153	64,100	40	33	20
		152	64,000	41	30	20
Ore Blend 2	UBZ-4	134	49,400	43	33	26
		133	52,900	41	37	25
		129	50,800	41	35	24
Phosphate Slag	UBZ-4	<2	26,900	43	<10	<5
		<2	29,400	42	<10	<5
		<2	31,000	42	<10	<5
Collier Coke	UBZ-4	2	657	<2	<10	6
		2	680	<2	<10	7
		2	659	<2	<10	5
Underflow Solids	UBZ-4	827	49,800	98	180	28
		791	51,500	99	170	27
		799	45,800	100	176	28
Phosphate Nodules	UBZ-2/UBZ-4	<2	102,000	34	11	14
		<2	89,200	34	<10	14
		<2	86,900	33	<10	13
Sweetwater Coke	UBZ-4	<2	146	5	<10	<5
		<2	162	5	<10	<5
		<2	147	5	<10	<5
SO_2 Cake	UBZ-4	2,700	2,400	10	865	<5
		2,730	2,350	9	811	<5
		2,720	2,530	10	837	<5

Notes:
NM: Not measured

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Table 3-4: TCLP Testing Results

Constituent	Slag Concentration[1] (mg/L)	Treater Dust Concentration[1] (mg/L)	Treater Dust Concentration[2] (mg/L)	Underflow Solids (prior to sulfiding)[3] (mg/L)	TLCP MCLs (mg/L)
Arsenic	<0.032	<0.044	0.05	0.87	5.0
Barium	<0.1	<0.1	<0.05	0.1	100
Cadmium	0.032	0.033	<0.05	16.8	1.0
Chromium	0.04	0.04	0.48	0.07	5.0
Lead	<0.03	<0.02	0.18	0.47	1.0
Mercury	<0.0005	<0.0005	<0.001	<0.0005	0.2
Selenium	<0.0035	<0.0035	<0.05	0.65	1.0
Silver	<0.02	<0.02	<0.05	<0.7	5.0

Notes:

NM: Not measured

1. Data from Phase I RI (Golder 1992)
2. Data collected by Monsanto (2006)
3. Data collected by Monsanto (1990)

Shaded cells exceed TCLP MCL.

Table 3-5: Source Area Assessment

Area	Potential Source Area	Potential Source Type	Potential Constituents	Potential Source of Constituents of Concern in Groundwater	Notes
UBZ-2	Old UFS Ponds	Primary - Remnant UFS	Cd, F, Mn, NO_3, Se	Yes	Closed in 1987
		Secondary - Vadose Zone	Cd, F, Mn	Yes	
	Nodules	Primary	F	Possible	Currently stockpiled in UBZ-2
	Treater Dust	Primary	F	Possible	Currently stockpiled in UBZ-2
	Sand	Primary	None	No	Currently stockpiled in UBZ-2
	Crushed Slag Fill	Primary	None	No	Currently stockpiled in UBZ-2
	Poured Molten Slag	Primary	None	No	Currently stockpiled in UBZ-2
	Cinders	Primary	None	No	Currently stockpiled in UBZ-2
	"Tailings" Pond	Primary	Mo, SO_4, Cl, Cd, Mn, F	Possible	Closure status unknown, covered in crushed slag
		Secondary-Vadose Zone?	Cd, Mn, F	Possible	
UBZ-4	Old Hydroclarifier	Primary - Remnant UFS	Cd, F, Mn, NO_3, Se	Yes	Replaced in 1985 with lined facility. Likely captured entirely by Plant production wells
		Secondary - Vadose Zone	Cd, F, Mn		
	Northwest Pond	Primary - Remnant UFS	Cd, F, Mn, NO_3, Se	Yes	Out of service in 1983, converted to permitted landfill in 1987. Some groundwater flow on west side of pond may not be captured by Plant porodcution wells.
		Secondary - Vadose Zone	Cd, F, Mn	Yes	
	Old UFS Ponds	Primary - Remnant UFS	Cd, F, Mn, NO_3, Se		Covered with underflow solids and nodules by 1985, no closure information Likely captured entirely by Plant production wells
		Secondary - Vadose Zone	Cd, F, Mn	Possible	
	Coke	Primary	None	No	Captured by Plant production wells
	Ore Blends and Nodules	Primary	Cd, F, Mn, NO_3, Se	Possible	Captured by Plant production wells
	Quartzite	Primary	None	No	Captured by Plant production wells
	UFS Piles	Primary	Cd, F, Mn, NO_3, Se	Possible	Currently stockpiled in UBZ-4, within capture zone of Plant wells
	Treater Dust	Primary	F	Possible	Currently stockpiled in UBZ-4, within capture zone of Plant wells
	Crushed Slag Fill	Primary	None	No	Currently stockpiled in UBZ-4, within capture zone of Plant wells
	Poured Molten Slag	Primary	None	No	Currently stockpiled in UBZ-4, within capture zone of Plant wells
UBZ-1	Coke and Quartzite Ponds	Primary	None	No	Out of service in 1987, filled with molten slag
	Effluent Settling Pond	Primary	Cd, F, Mn, NO_3, Se	Possible	Water sourced from Plant Wells PW-01, PW-02, and PW-03. Taken out of service between 1995 and 1998 and filled with molten slag.
	Sewage Evaporation Ponds	Primary	Cl, NO_3	Yes	Out of service in 1993, filled with molten slag
	Crushed Slag Fill	Primary	None	No	Currently stockpiled in UBZ-1
	Poured Molten Slag	Primary	None	No	Currently stockpiled in UBZ-1
Plant Roads - All Areas	Roads Treated with MgCL	Primary	Cl	Yes	Infiltration of magnesium chloride dust suppressant (~1999-2007)

Notes:
Source areas shown on Figure 3-1

Table 6-1: UBZ-2 Source Area Preliminary Conceptual Model Summary

COMPONENT					
Hydrogeology		**Old UFS Ponds and Vicinity Source Area Characteristics**		**Potential Release Mechanisms**	
UBZ-2 Aquifer	Permeable interflow zones interbeded with low-permeability basalt flows	**Pond Operations**	Before 1970 to 1985, closed 1987	**Infiltration of precipitation**	Dissolution of mineral phases, mobilization of constituents in vadose zone below sources
Hydraulic Conductivity (ft/d)	300 to 600 ft/d in Old UFS Ponds area, < 1 to 1,000 ft/d in UBZ-2.	**Pond Floor Elevation (feet msl)**	5,936 ft (minimum)	**Fluctuating groundwater levels**	Dissolution of mineral phases, mobilization of constituents in vadose zone below sources
Effective Porosity	Estimated 15 to 30% in interflow zones, 0.1 to 1% in flow interiors	**Materials**	Underflow Solids and Minerals precipitated in vadose zone below the ponds	**Transport of chloride from soils to vadose zone**	Dissolution of otavite and generation of CdCl complexes
Groundwater Velocity (ft/d)	1 to 2	**Closure**	Excavation, molten slag fill, bentonite and crushed slag cap	**Infiltration of seasonally ponded snowmelt runoff**	Dissolution of mineral phases, mobilization of constituents in vadose zone below sources
Groundwater Elevation (feet msl)	5,890 to 5,895	**Remnant Materials**	35,000 tons and precipitated solids below ponds	**Infiltration through stockpile materials**	Mobilization of constituents and transport to groundwater
Groundwater Flow Direction	Southeast and south	**Other stockpiled materials in UBZ-2**	Nodules, treater dust, sand, cinders, crushed slag	**Infiltration through tailings or unidentified disposal area**	Mobilization of constituents and transport to groundwater
Groundwater System Boundaries	Monsanto and Subsidiary Faults	**Other sources**	"Tailings" near TW-22,23 and 24. Unidentified disposal area		

Notes:
Groundwater elevation based on TW-37.

Table 7-1: Proposed Analytical Parameters for Remnant Source and Vadose Zone Materials

Test Type	Analytical Parameter	Proposed Test Methods
Elemental Analysis	Alumium	EPA 3050b
	Arsenic	EPA 3050b
	Cadmium	EPA 3050b
	Calcium	EPA 3050b
	Chromium	EPA 3050b
	Iron	EPA 3050b
	Lead	EPA 3050b
	Magnesium	EPA 3050b
	Manganese	EPA 3050b
	Molybdenum	EPA 3050b
	Nickel	EPA 3050b
	Potassium	EPA 3050b
	Selenium	EPA 3050b
	Silicon	EPA 3050b
	Sodium	EPA 3050b
	Strontium	EPA 3050b
	Zinc	EPA 3050b
	Sulfur (total)	EPA 3050b
Leach Testing (SPLP and Groundwater Leaching)	pH	EPA 1312
	Condcutivity	EPA 1312
	Total Dissolved Solids	EPA 1312
	Chloride	EPA 1312
	Sulfate	EPA 1312
	Alkalinity	EPA 1312
	Nitrate	EPA 1312
	Fluoride	EPA 1312
	Alumium	EPA 1312
	Arsenic	EPA 1312
	Cadmium	EPA 1312
	Calcium	EPA 1312
	Chromium	EPA 1312
	Iron	EPA 1312
	Lead	EPA 1312
	Magnesium	EPA 1312
	Manganese	EPA 1312
	Molybdenum	EPA 1312
	Nickel	EPA 1312
	Potassium	EPA 1312
	Selenium	EPA 1312
	Silicon	EPA 1312
	Sodium	EPA 1312
	Strontium	EPA 1312
	Zinc	EPA 1312
	Sulfur (total)	EPA 1312

Notes:
Detection limits to be confirmed by analytical laboratory

Table 7-2: Proposed Borehole and Test Pit Locations

Location	Exploration Type	Designation	Easting	Northing	Description
Old UFS Ponds	Borehole and Monitoring Well	TW-71	-12,380	11,735	Source Area Characterization and Groundwater Quality
	Borehole and Monitoring Well	TW-72	-12,300	11,080	Source Area Characterization and Groundwater Quality
	Borehole and Monitoring Well	TW-73	-12,150	10,740	Downgradient Groundwater Quality
Unidentified Disposal Area	Borehole and Monitoring Well	TW-74	-12,340	12,480	Source Area Characterization and Groundwater Quality
"Tailings" Pond	Test Pit	TP-1	-12,510	9,820	Source Area Characterization
	Test Pit	TP-2	-12,540	9,660	Source Area Characterization
	Test Pit	TP-3	-12,550	9,990	Source Area Characterization
	Test Pit	TP-4	-12,580	10,230	Source Area Characterization
	Test Pit	TP-5	-12,460	10,330	Source Area Characterization
	Test Pit	TP-6	-12,520	10,470	Source Area Characterization
	Test Pit	TP-7	-12,420	10,560	Source Area Characterization
	Borehole and Monitoring Well	TW-75	-12,290	9,900	Source Area Characterization and Groundwater Quality
	Borehole and Monitoring Well	TW-76	-12,470	10,250	Source Area Characterization and Groundwater Quality

Notes:
Locations are approximate and will be confirmed following field confirmation of access

FIGURES

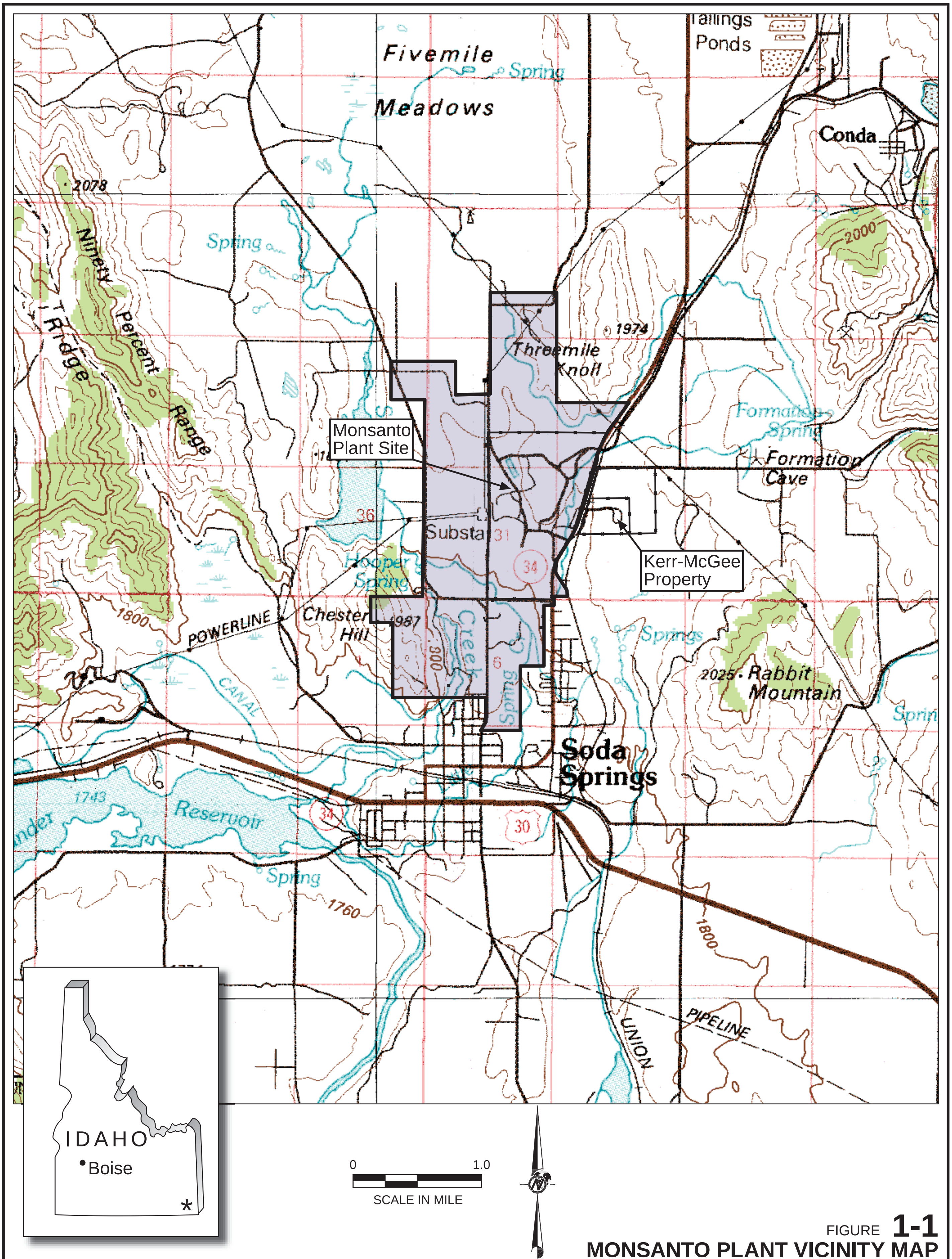

FIGURE **1-1**

MONSANTO PLANT VICINITY MAP

MONSANTO/SODA SPRINGS 5 YR REVIEW - ANNUAL GW+SW SAMPLING/UBZ-2 INVEST.

Source: *Topographic map of the USGS Soda Springs Quadrangle (1:100,000) 1982.*

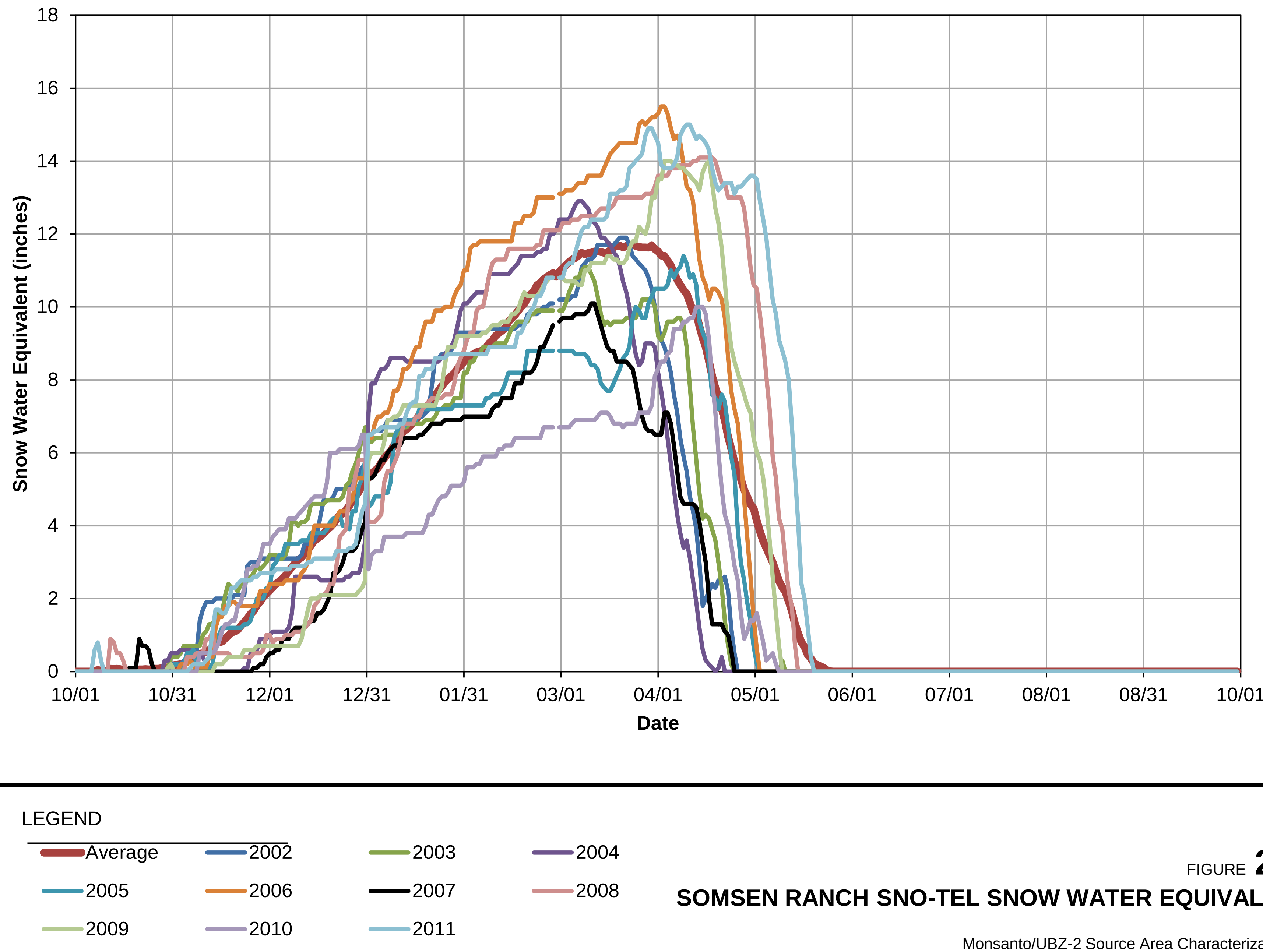

FIGURE **2-1**

SOMSEN RANCH SNO-TEL SNOW WATER EQUIVALENT

Monsanto/UBZ-2 Source Area Characterization/ID

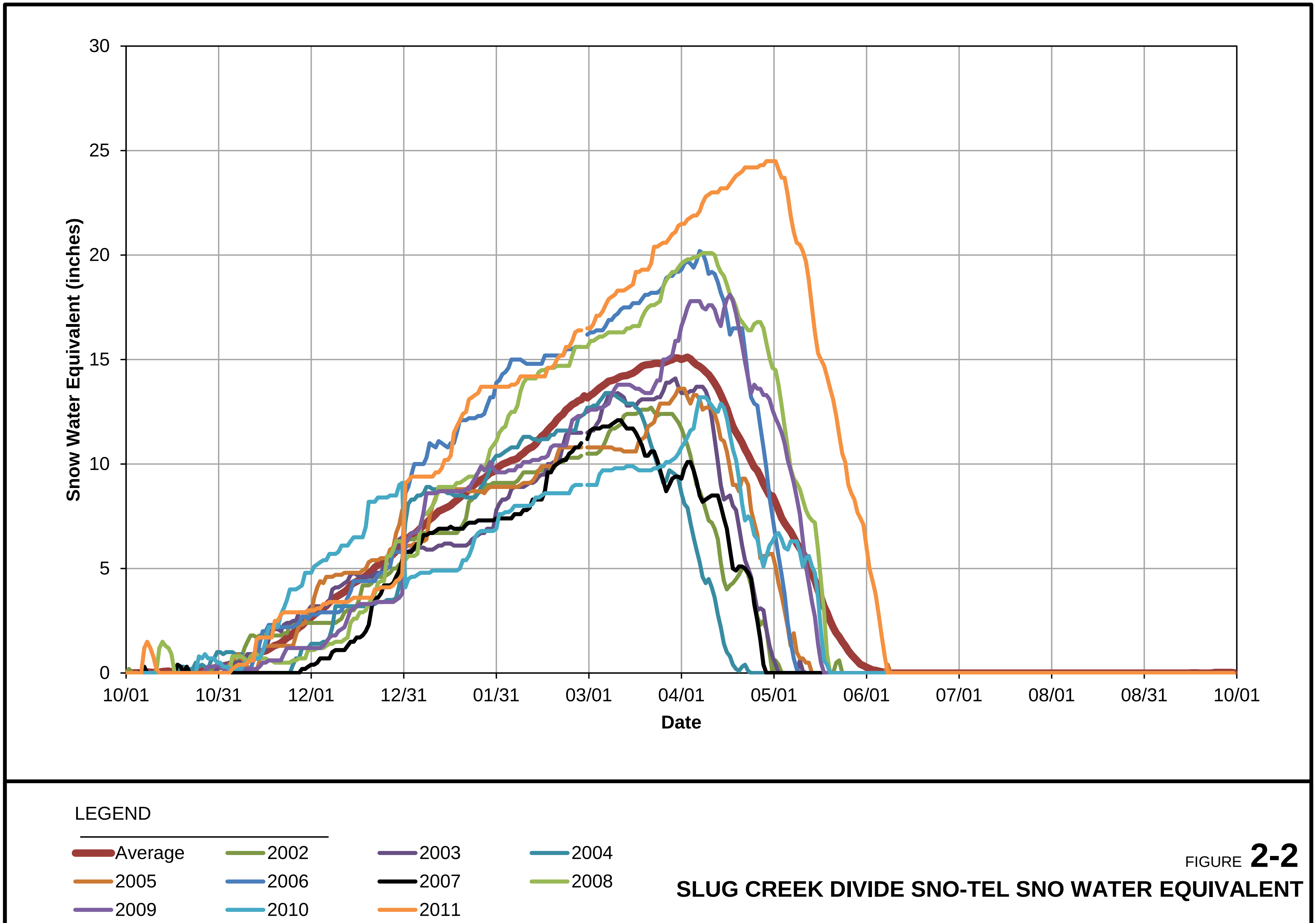

FIGURE **2-2**

SLUG CREEK DIVIDE SNO-TEL SNO WATER EQUIVALENT

Monsanto/UBZ-2 Source Area Characterization/ID

Figures 2-1 and 2-2.xlsx

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LEGEND:

f —U/D— f	FAULT	TW-60	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-1	MORMON A	SPRING LOCATION WITH NAME (WHERE KNOWN)
f —U ? D— f	FAULT (INFERRED)	LEWIS	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-2	DOC	SPRING LOCATION (NOT SAMPLED) WITH NAME (WHERE KNOWN)
f .... f	FISSURE	TW-56	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-3	MORMON CREEK	SURFACE WATER LOCATION WITH NAME
UBZ-1	GROUNDWATER ZONE	TW-33	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4	*	POINT OF COMPLIANCE LOCATION
		PW-1	PRODUCTION WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4		

0 1000 2000

SCALE IN FEET

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/2/2003).
SITE TOPOGRAPHY FROM AERIAL MAPPING, INC., IDAHO (5/11/1996).

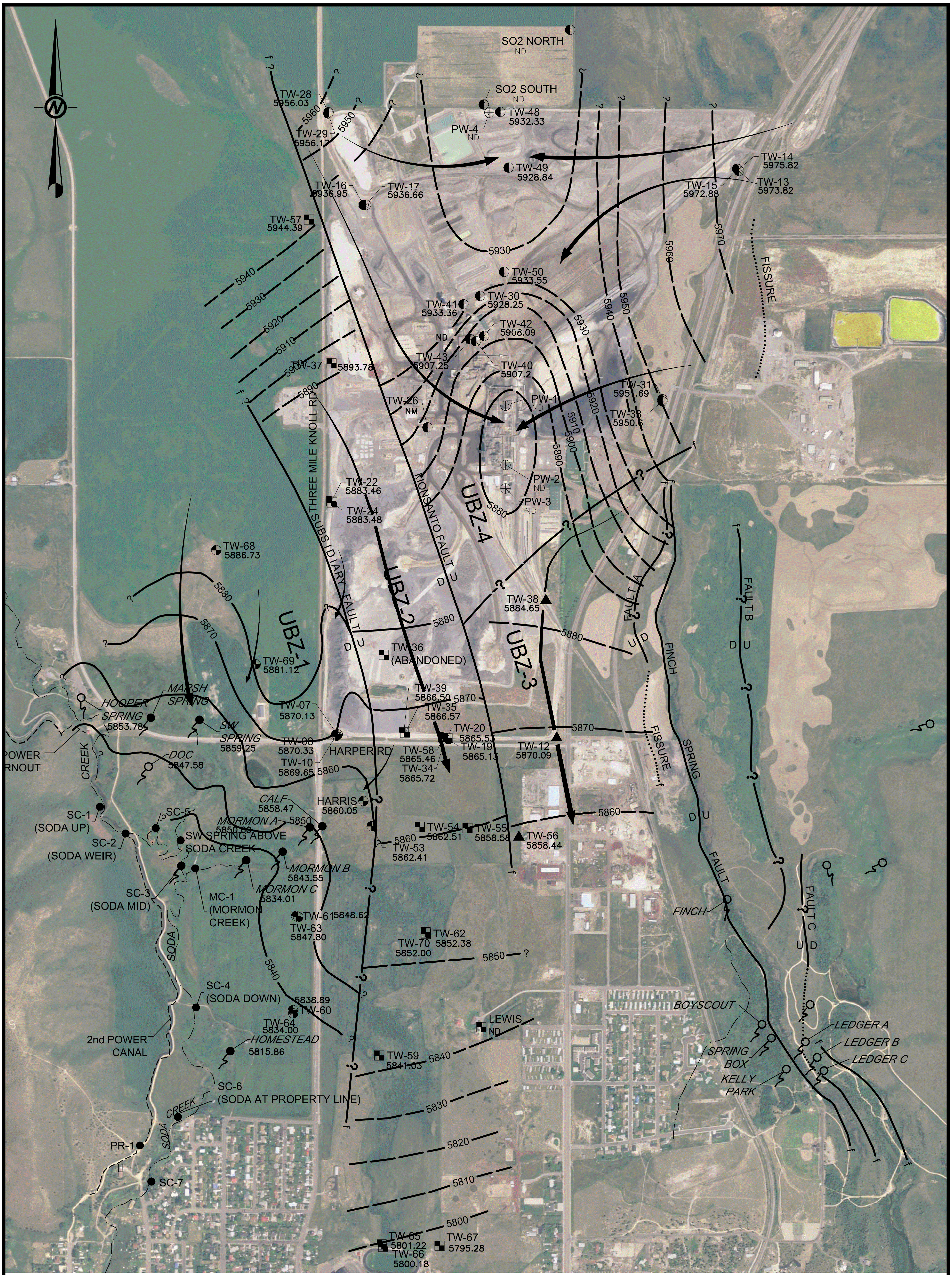
FIGURE **2-3**

LOCATION OF SPRINGS AND WELLS IN THE UPPER BASALT ZONE

Monsanto/Soda Springs 5 yr Review - Annual GW+SW Sampling/UBZ-2 Invest.

K:\CAD\Projects\1991\9131101\x002\002\2G\913-1101_002_002_2G_F2-3_F2-4_F3-1.dwg | F2-3 | Mod: 07/24/2012, 08:23 | Plotted: 07/27/2012, 09:09 | NDieterich

Golder Associates



LEGEND:

f —U— f	FAULT
f —U ? D— f	FAULT (INFERRED)
f ······ f	FISSURE
UBZ-1	GROUNDWATER ZONE
←	GROUNDWATER FLOW DIRECTION
— 5840 —	GROUNDWATER CONTOUR (10 FOOT INTERVAL)
MORMON A	SPRING LOCATION WITH NAME (WHERE KNOWN)
DOC	SPRING LOCATION (NOT SAMPLED) WITH NAME (WHERE KNOWN)
MORMON CREEK	SURFACE WATER LOCATION WITH NAME
TW-60 5837.68	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-1
TW-59 5839.05	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-2
TW-56 5853.05	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-3
TW-28 5948.04	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4
PW-1 ND	PRODUCTION WELL LOCATION WITH NAME

GROUNDWATER ELEVATION (FEET) WITH QUALIFIER (IF ANY)

ND = NO DATA

0 1000 2000

SCALE IN FEET

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/2/2003).
SITE TOPOGRAPHY FROM AERIAL MAPPING, INC., IDAHO (5/11/1996).
WELL LOCATIONS BY GOLDER ASSOCIATES, (12/12/2001).

FIGURE **2-4**

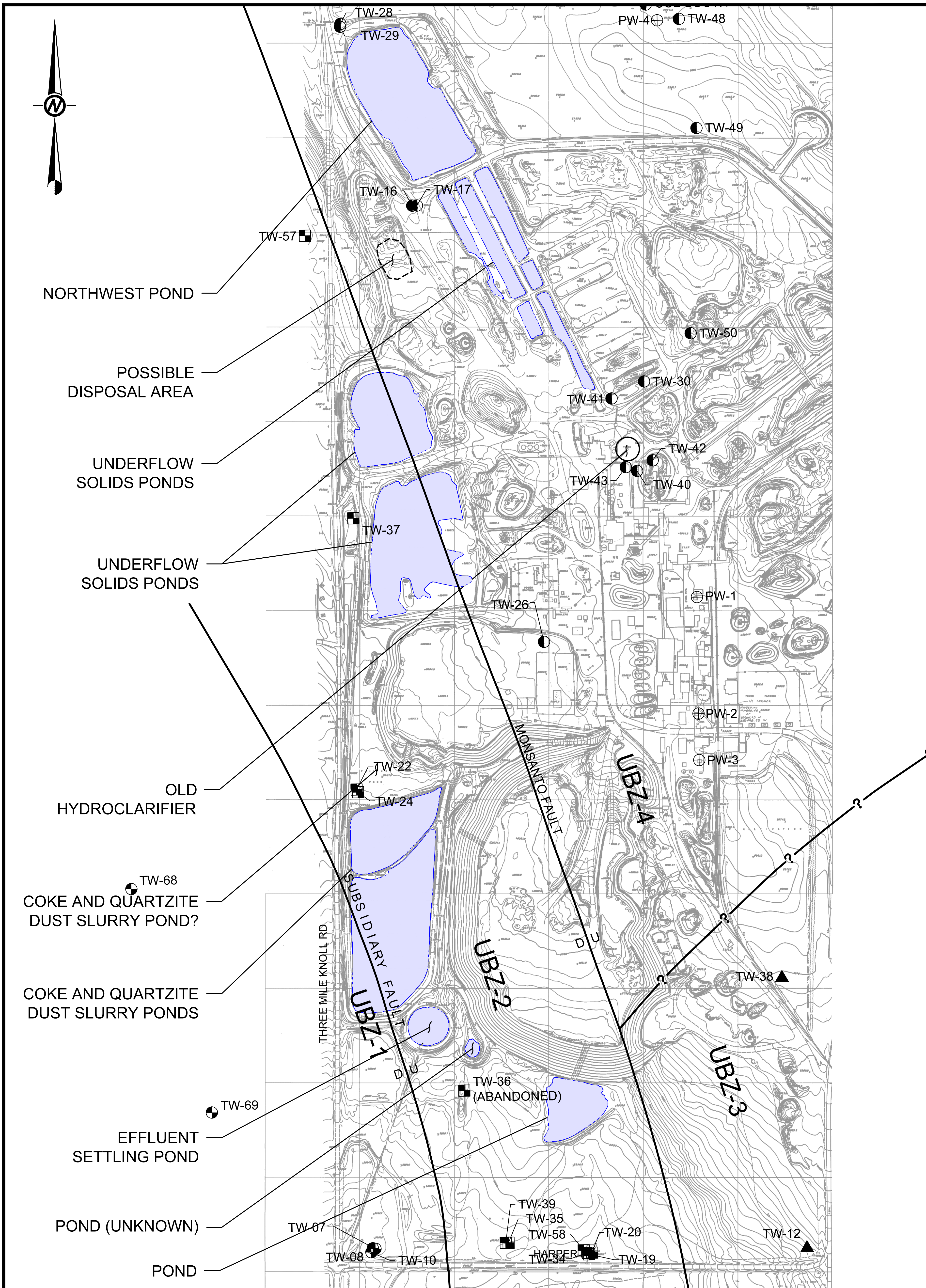
GROUNDWATER ELEVATION IN THE UPPER BASALT ZONE (MAY 2011)

Monsanto/Soda Springs 5 yr Review - Annual GW+SW Sampling/UBZ-2 Invest.

0 1000 2000
SCALE IN FEET

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/2/2003).
SITE TOPOGRAPHY FROM AERIAL MAPPING, INC., IDAHO (5/11/1996).
WELL LOCATIONS BY GOLDER ASSOCIATES, (12/12/2001).

FIGURE **3-1**
MONSANTO FACILITY MAP
Monsanto/Soda Springs 5 yr Review - Annual GW+SW Sampling/UBZ-2 Invest.



LEGEND:

FAULT (U/D)	FAULT	TW-60	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-1	TW-33	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4
U ? D	FAULT (INFERRED)	LEWIS	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-2	PW-1	PRODUCTION WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4
....	FISSURE	TW-56	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-3		
UBZ-1	GROUNDWATER ZONE				

0 500 1000
SCALE IN FEET

SOURCE:
TOPOGRAPHY COMPILED FROM AERIAL PHOTOGRAPHS BY AERO SERVICE CORPORATION (10/15/1970).

FIGURE **3-2**

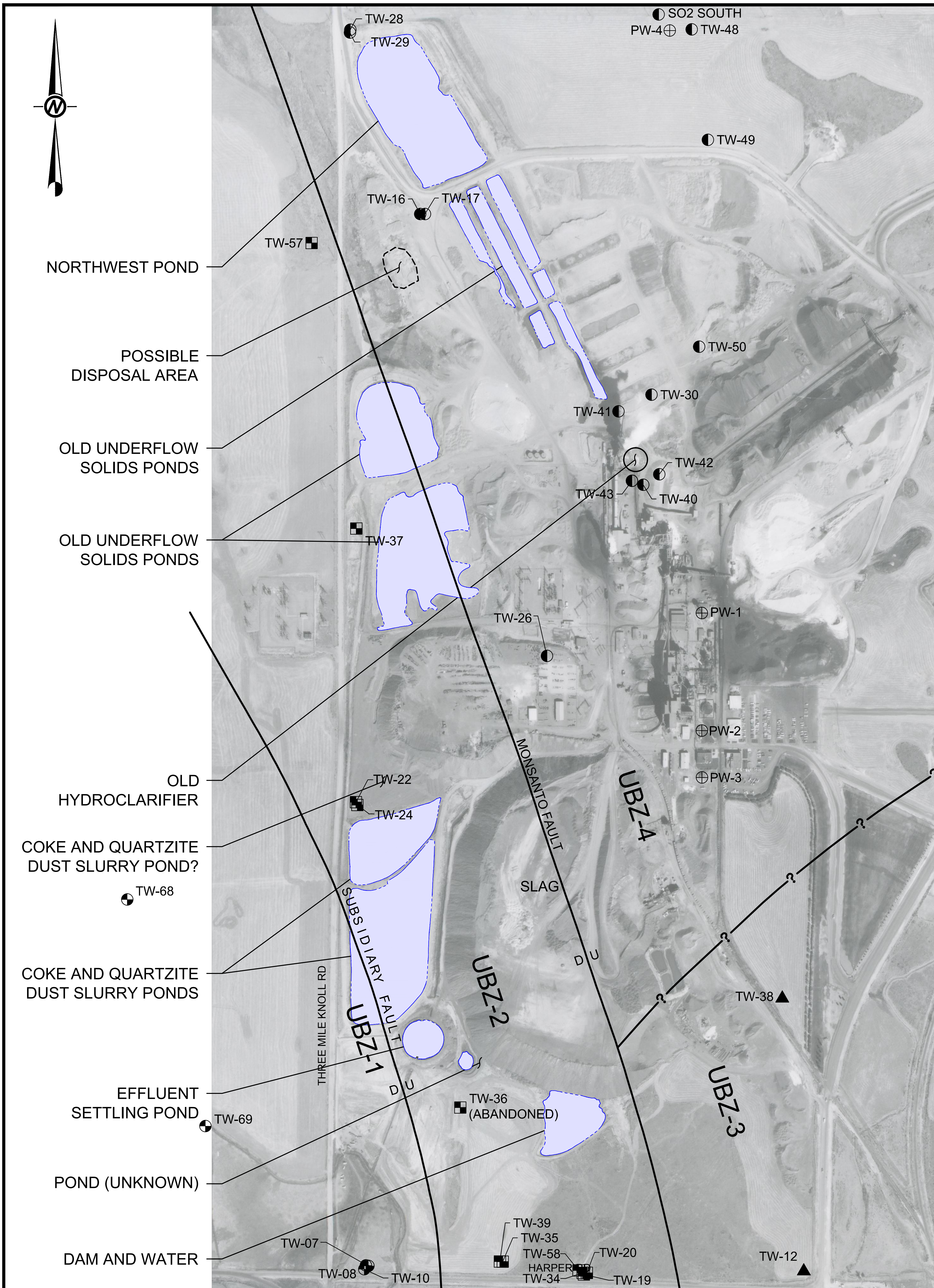
1970

TOPOGRAPHIC MAP

Monsanto/Soda Springs 5 yr Review - Annual GW+SW Sampling/UBZ-2 Invest.

K:\CAD\Projects\1991\9131101\x002\002\2G\913-1101_002_002_2G_F3-2.dwg | F3-2 | Mod: 07/24/2012, 08:24 | Plotted: 07/27/2012, 09:17 | NDieterich

Golder Associates



LEGEND:

FAULT		TW-60	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-1	TW-33	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4
FAULT (INFERRED)		LEWIS	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-2	PW-1	PRODUCTION WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4
FISSURE		TW-56	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-3		
UBZ-1	GROUNDWATER ZONE				

0 500 1000

SCALE IN FEET

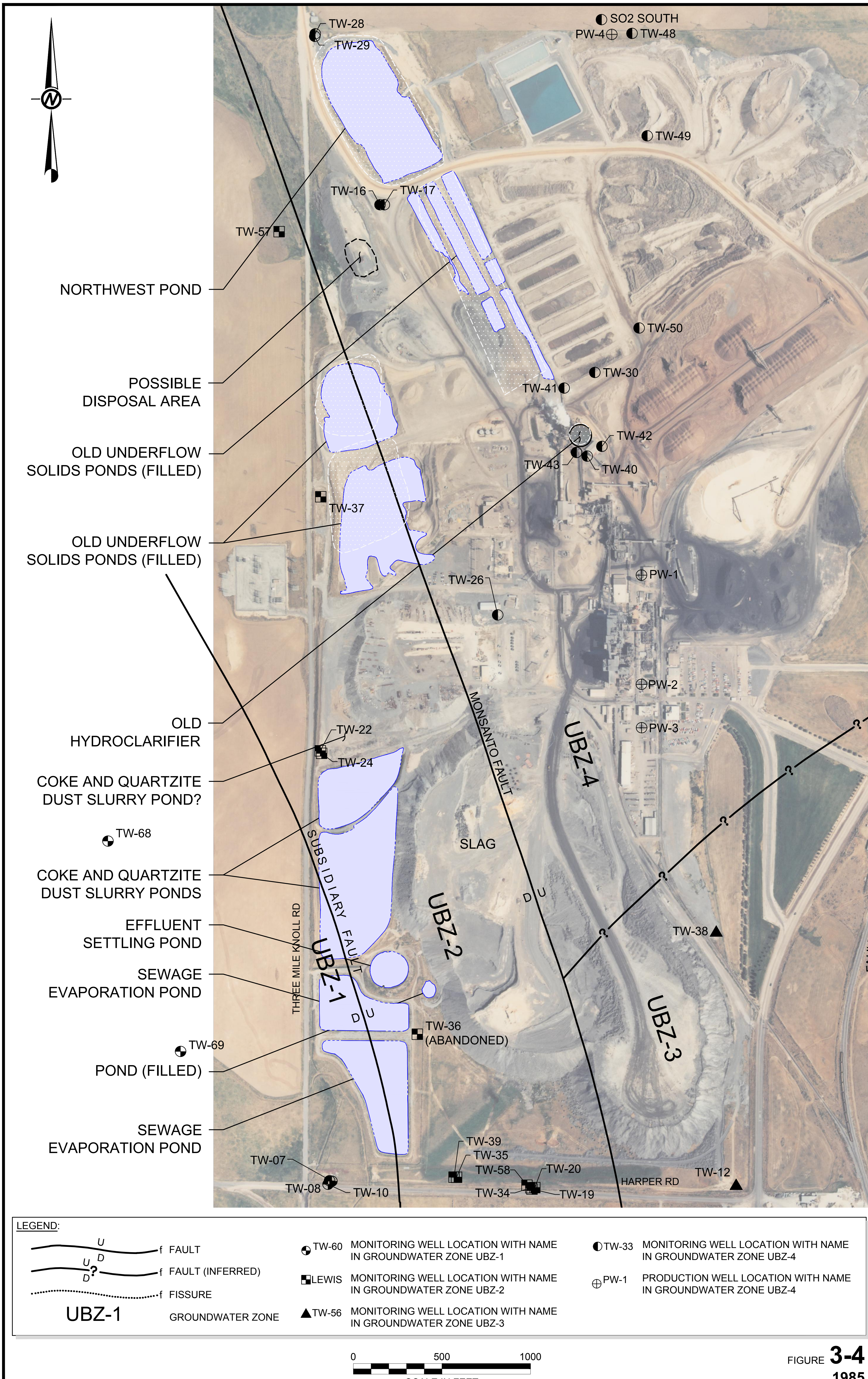
SOURCE:
AERIAL PHOTO FROM MONSANTO

FIGURE **3-3**

1974

AERIAL PHOTOGRAPH

Monsanto/Soda Springs 5 yr Review - Annual GW+SW Sampling/UBZ-2 Invest.



SOURCE:
AERIAL PHOTO FROM MONSANTO (7/21/1985).

FIGURE **3-4**

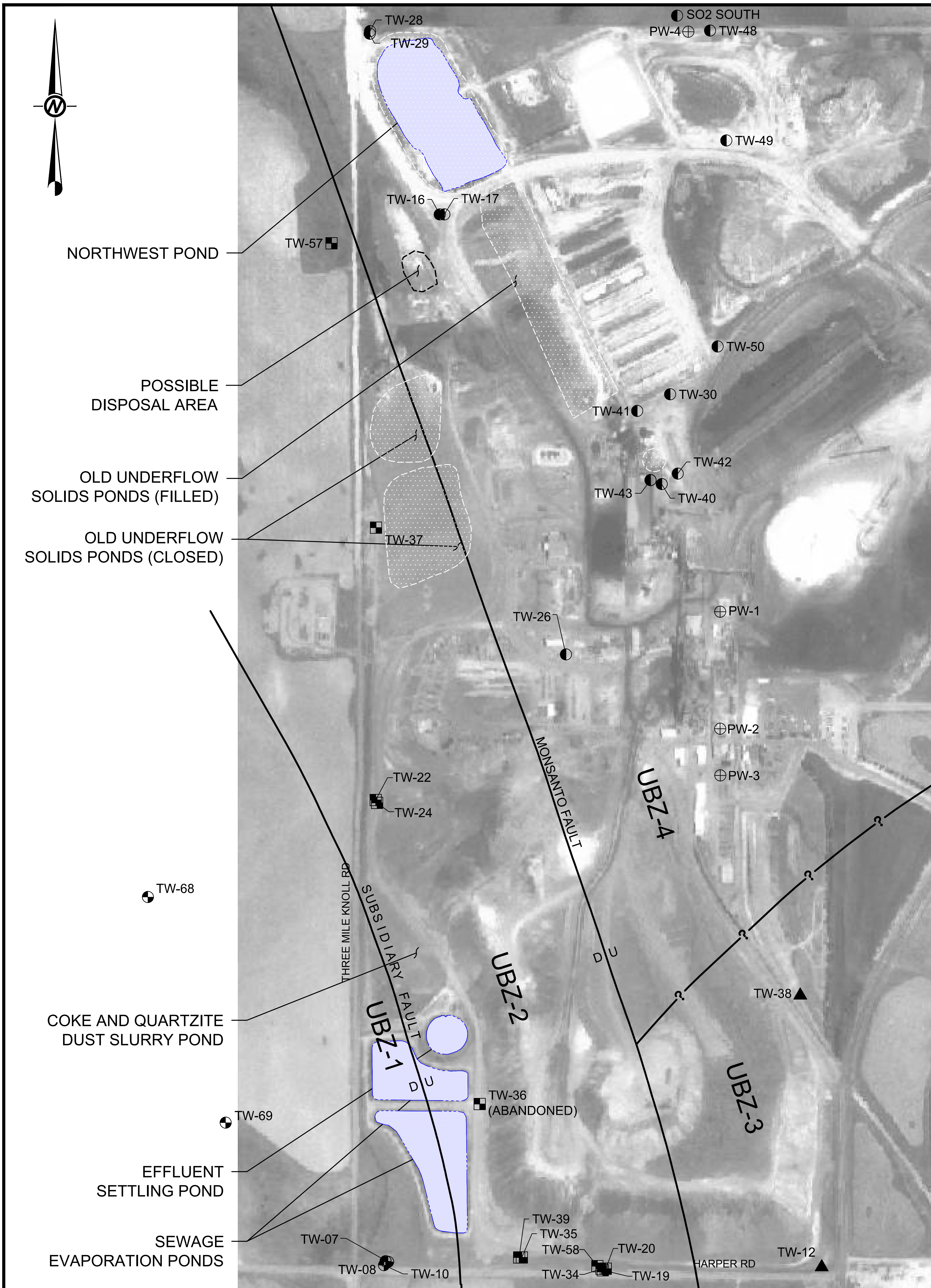
1985

AERIAL PHOTOGRAPH

Monsanto/Soda Springs 5 yr Review - Annual GW+SW Sampling/UBZ-2 Invest.

K:\CAD\Projects\1991\9131101\x002\002\2G\913-1101_002_002_2G_F3-4.dwg | F3-4 | Mod: 07/24/2012, 08:26 | Plotted: 07/27/2012, 09:27 | NDieterich

Golder Associates



LEGEND:

(line)	FAULT	TW-60	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-1	TW-33	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4
?	FAULT (INFERRED)	LEWIS	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-2	PW-1	PRODUCTION WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4
(dotted)	FISSURE	TW-56	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-3		
UBZ-1	GROUNDWATER ZONE				

0 500 1000
SCALE IN FEET

SOURCE:
AERIAL PHOTO FROM MONSANTO.

FIGURE **3-5**

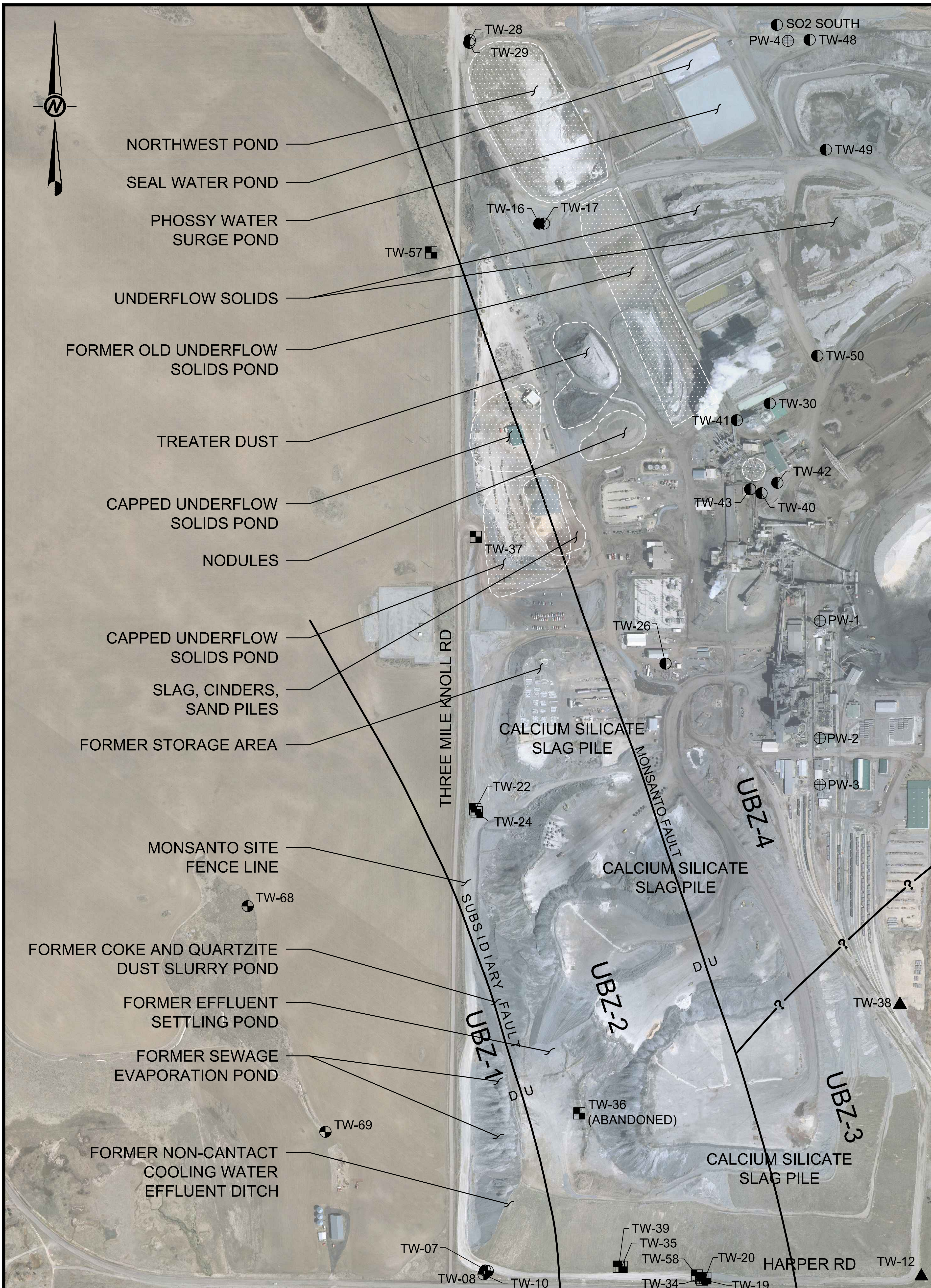
1992

AERIAL PHOTOGRAPH

Monsanto/Soda Springs 5 yr Review - Annual GW+SW Sampling/UBZ-2 Invest.

K:\CAD\Projects\1991\9131101\x002\002\2G\913-1101_002_002_2G_F3-5.dwg | F3-5 | Mod: 07/24/2012, 08:34 | Plotted: 07/27/2012, 09:30 | NDieterich

Golder Associates



LEGEND:

(line)	FAULT	TW-60	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-1	TW-33	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4
—?—	FAULT (INFERRED)	LEWIS	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-2	PW-1	PRODUCTION WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4
(dotted)	FISSURE	TW-56	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-3		
UBZ-1	GROUNDWATER ZONE				

0 500 1000
SCALE IN FEET

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/18/2011).

FIGURE **3-6**

2011

AERIAL PHOTO AND FORMER SOURCE AREAS

Monsanto/Soda Springs 5 yr Review - Annual GW+SW Sampling/UBZ-2 Invest.

K:\CAD\Projects\1991\9131101\x002\002\2G\913-1101_002_002_2G_F3-6.dwg | F3-6 | Mod: 07/24/2012, 08:17 | Plotted: 07/27/2012, 09:31 | NDieterich

Golder Associates

0 500 1000
SCALE IN FEET

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/18/2011).

FIGURE **3-7**

UBZ-2 SOURCE AREA CHARACTERIZATION
CROSS SECTION LOCATION MAP

Monsanto/Soda Springs 5 yr Review - Annual GW+SW Sampling/UBZ-2 Invest.

Golder Associates

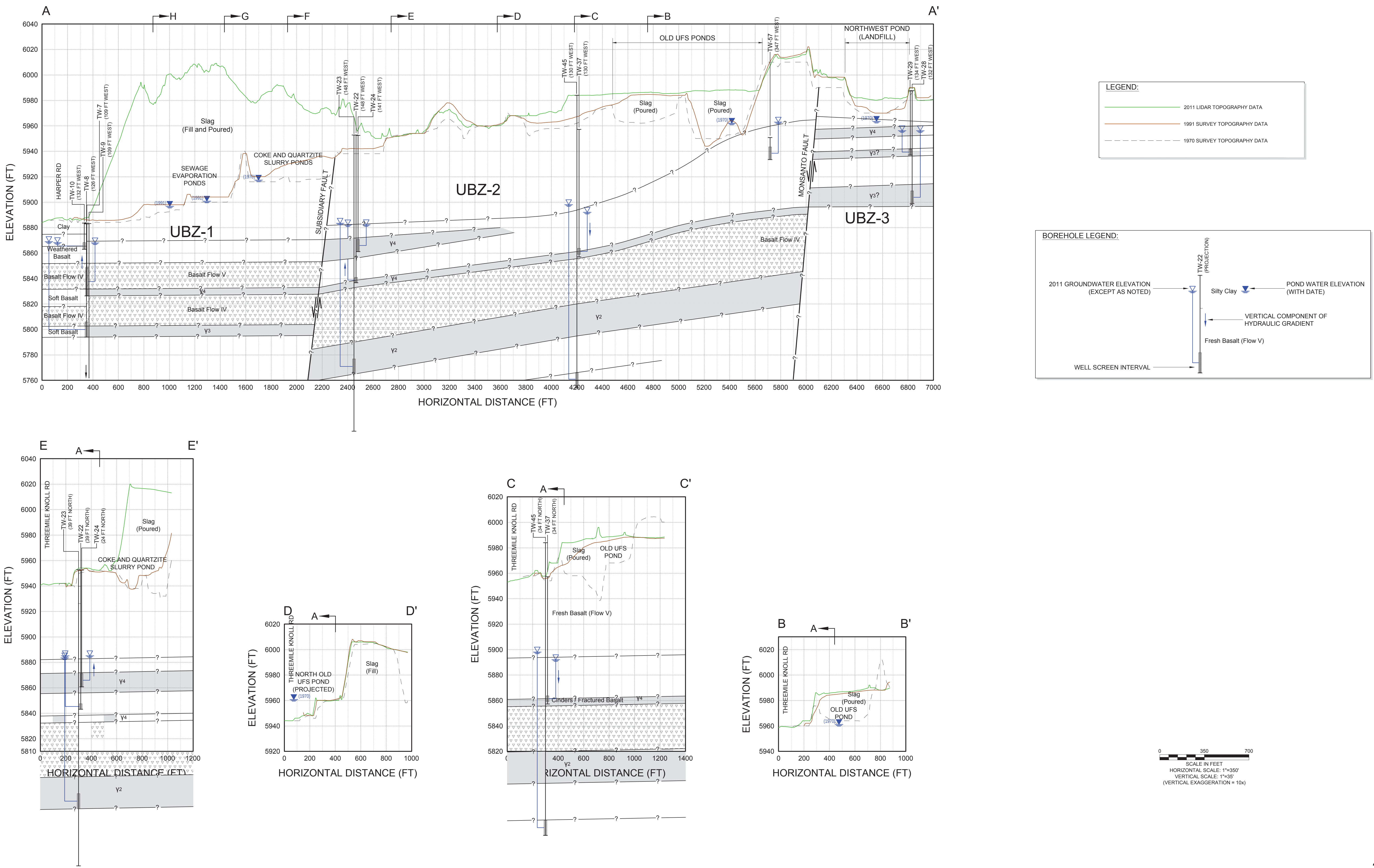


FIGURE **3-8**

UBZ-2 SOURCE AREA CHARACTERIZATION

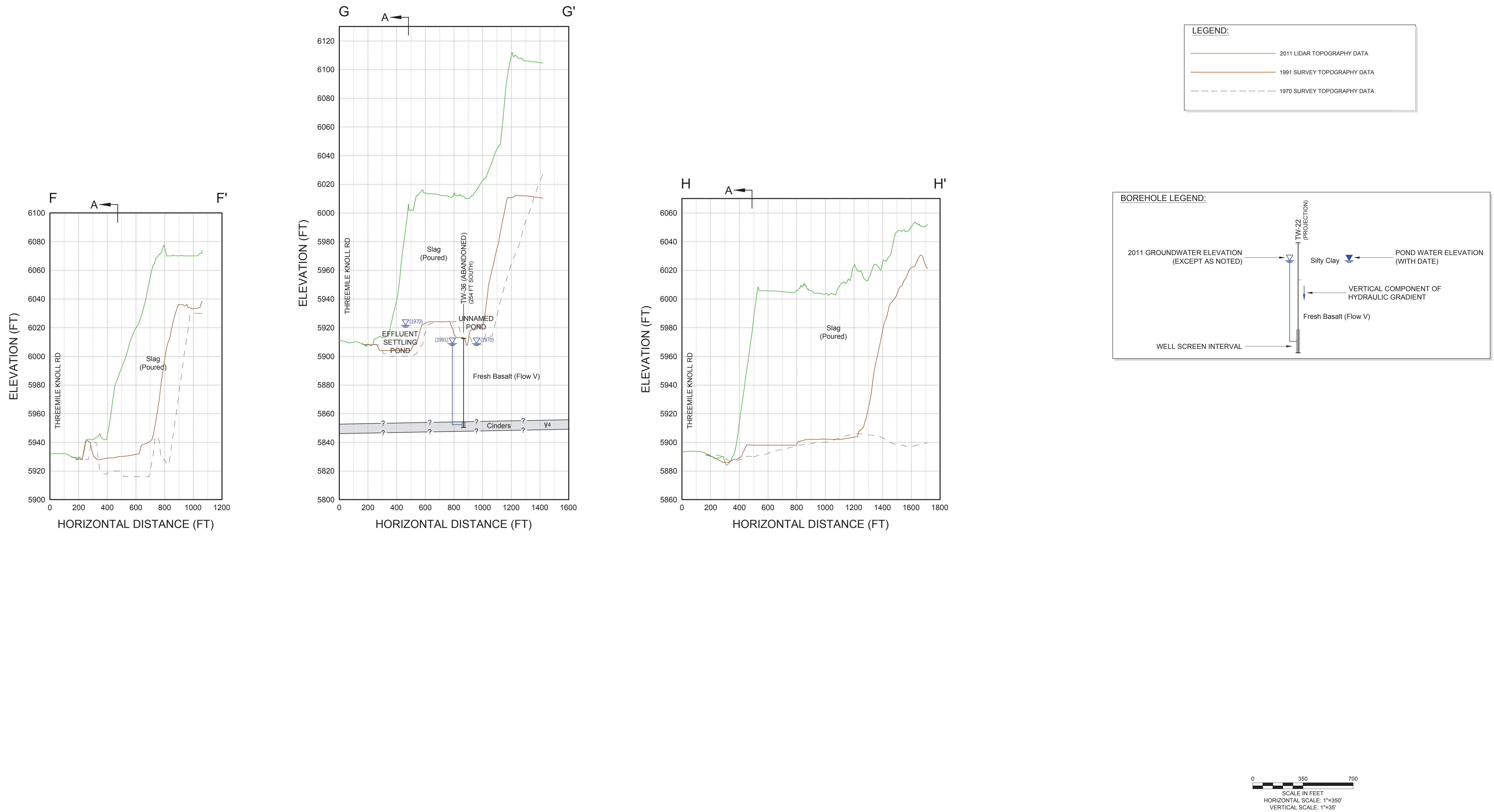
UBZ-2 CROSS SECTIONS A-A' TO E-E'

Monsanto/Soda Springs 5 yr Review - Annual GW+SW Sampling/UBZ-2 Invest.

SOURCE:
SITE TOPOGRAPHY FROM MONSANTO (5/18/2012).

K:\CAD\Projects\1991\9131101\x002\002\2G\913-1102-002_002_2G_F3-7_F3-8_F3-9_F3-10.dwg | F3-8 | Mod: 07/24/2012, 08:19 | Plotted: 07/24/2012, 08:35 | NDieterich

Golder Associates



SOURCE:
SITE TOPOGRAPHY FROM MONSANTO (5/18/2012).

FIGURE **3-9**

UBZ-2 SOURCE AREA CHARACTERIZATION

UBZ-2 CROSS SECTIONS F-F' TO H-H'

Monsanto/Soda Springs 5 yr Review - Annual GW+SW Sampling/UBZ-2 Invest.

K:\CAD\Projects\1991\9131101\x002\002\2G\913-1102-002_002_2G_F3-7_F3-8_F3-9_F3-10.dwg | F3-9 | Mod: 07/24/2012, 08:19 | Plotted: 07/24/2012, 08:36 | NDieterich

Golder Associates

LEGEND:

MAGNESIUM CHLORIDE APPLICATION (~1999-2007)

0 500 1000

SCALE IN FEET

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/18/2011).

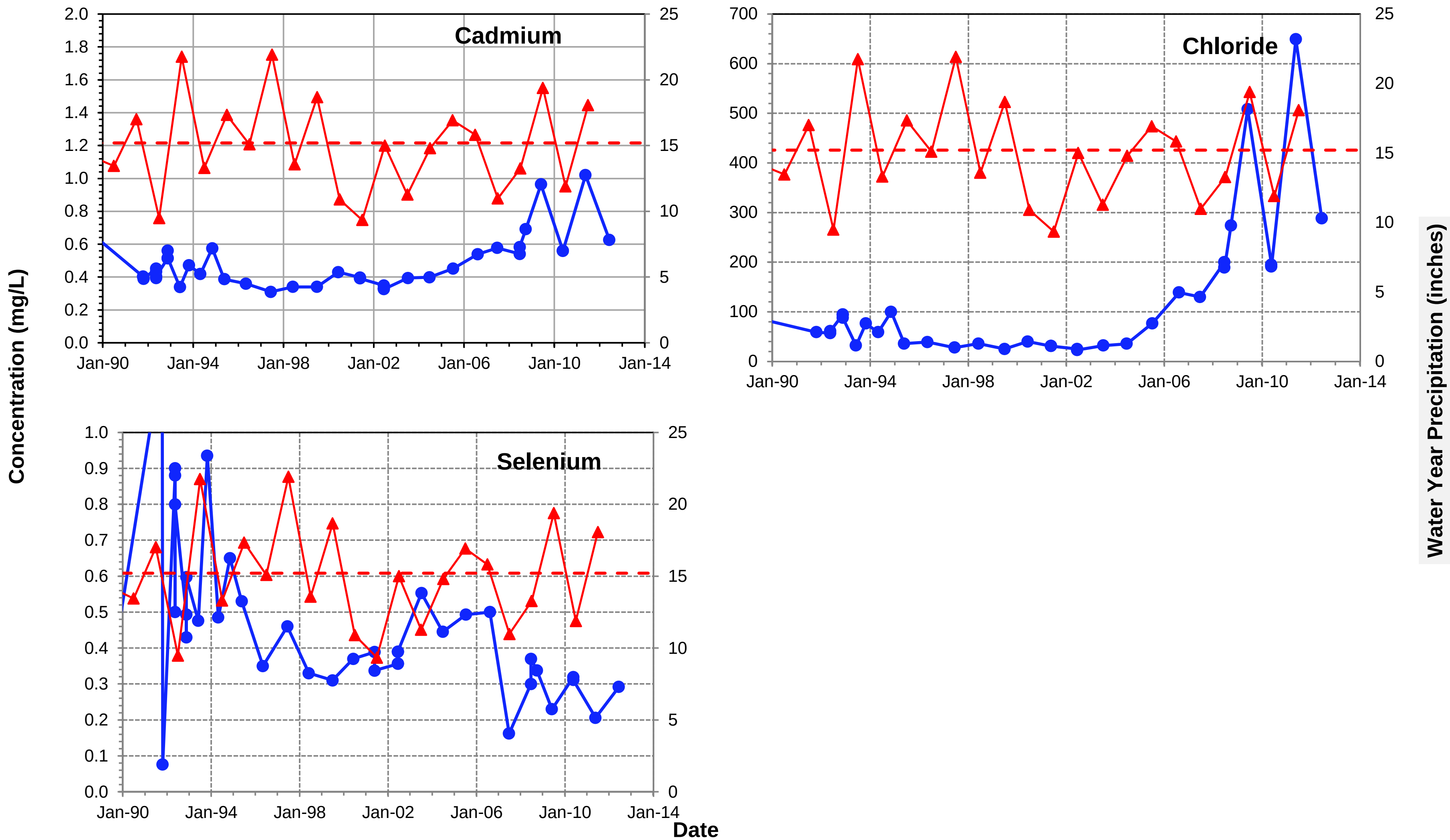
FIGURE **3-10**

LOCATIONS OF MAGNESIUM CHLORIDE APPLICATION

Monsanto/Soda Springs 5 yr Review - Annual GW+SW Sampling/UBZ-2 Invest.

K:\CAD\Projects\1991\9131101\x002\002\2G\913-1102-002_002_2G_F3-7_F3-8_F3-9_F3-10.dwg | F3-10 | Mod: 07/27/2012, 09:07 | Plotted: 07/27/2012, 09:34 | NDieterich

Golder Associates



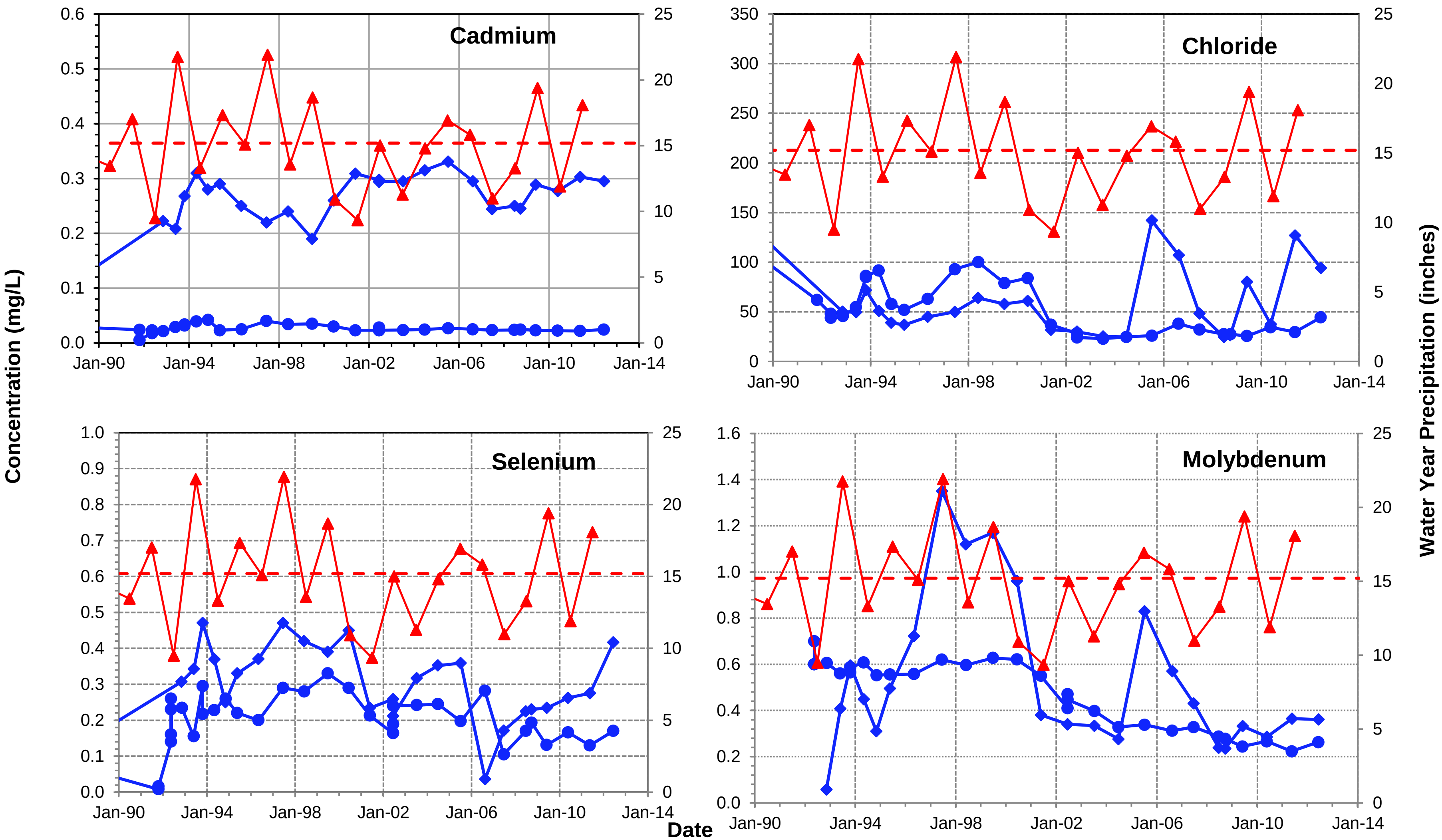
LEGEND

- Concentration
- Water Year Precipitation
- Average WY Precipitation

FIGURE **5-1**

TW-37 Constituent Concentrations and Water Year Precipitation

Monsanto/Source Area Charactrization/ID



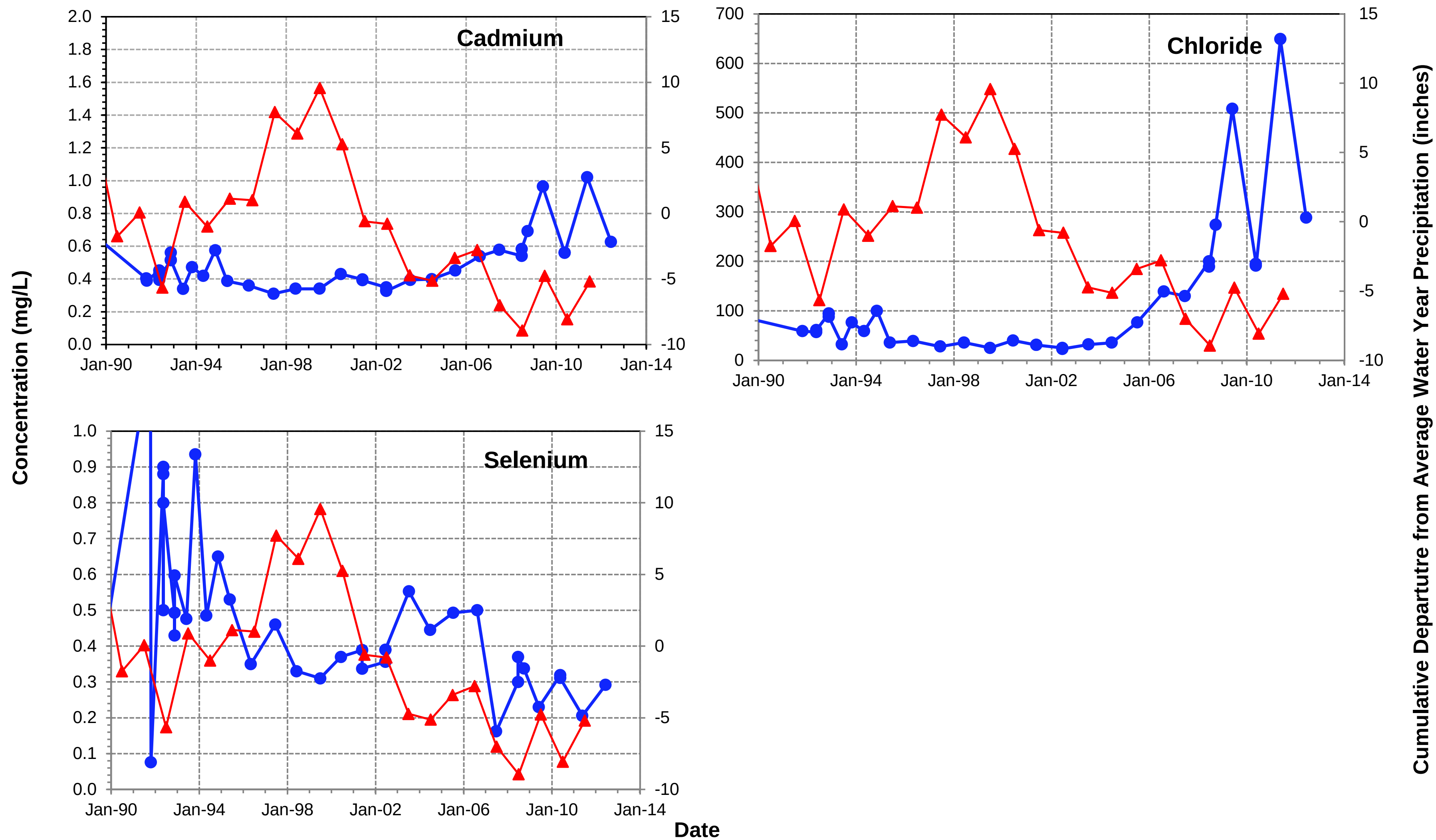
LEGEND

- TW-22
- TW-24
- Water Year Precipitation
- Average WY Precipitation

FIGURE **5-2**

TW-22 and TW-24 Constituent Concentrations and Water Year Precipitation

Monsanto/Source Area Charactrization/ID



LEGEND

Concentration

Departure from Average Water Year Precipitation since 1990

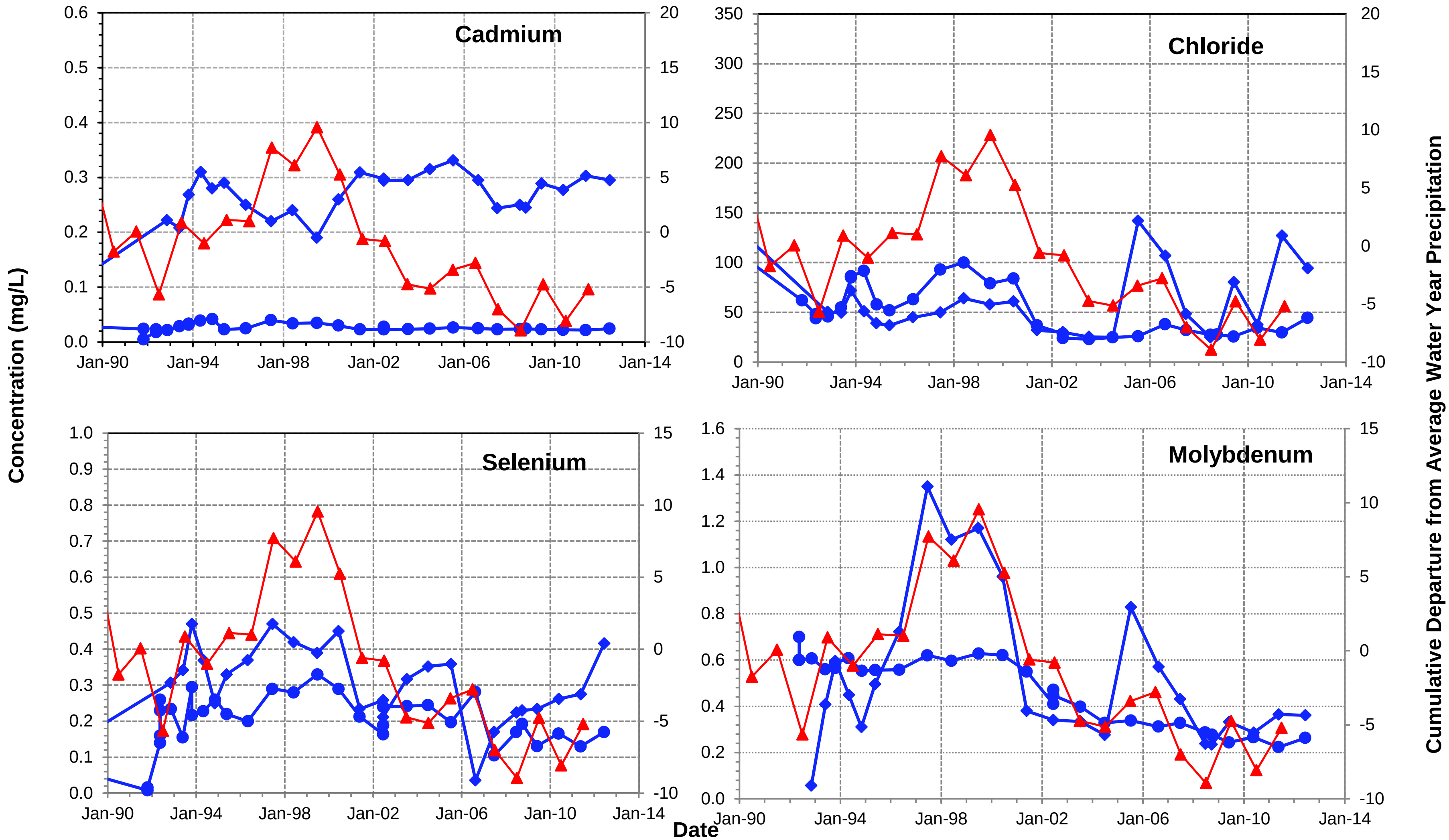
FIGURE **5-3**

TW-37 Constituent Concentrations and Departure from Average Water Year Precipitation

Monsanto/Source Area Charactrization/ID

Figures 5-1 to 5-4 rev.xlsx

Golder Associates



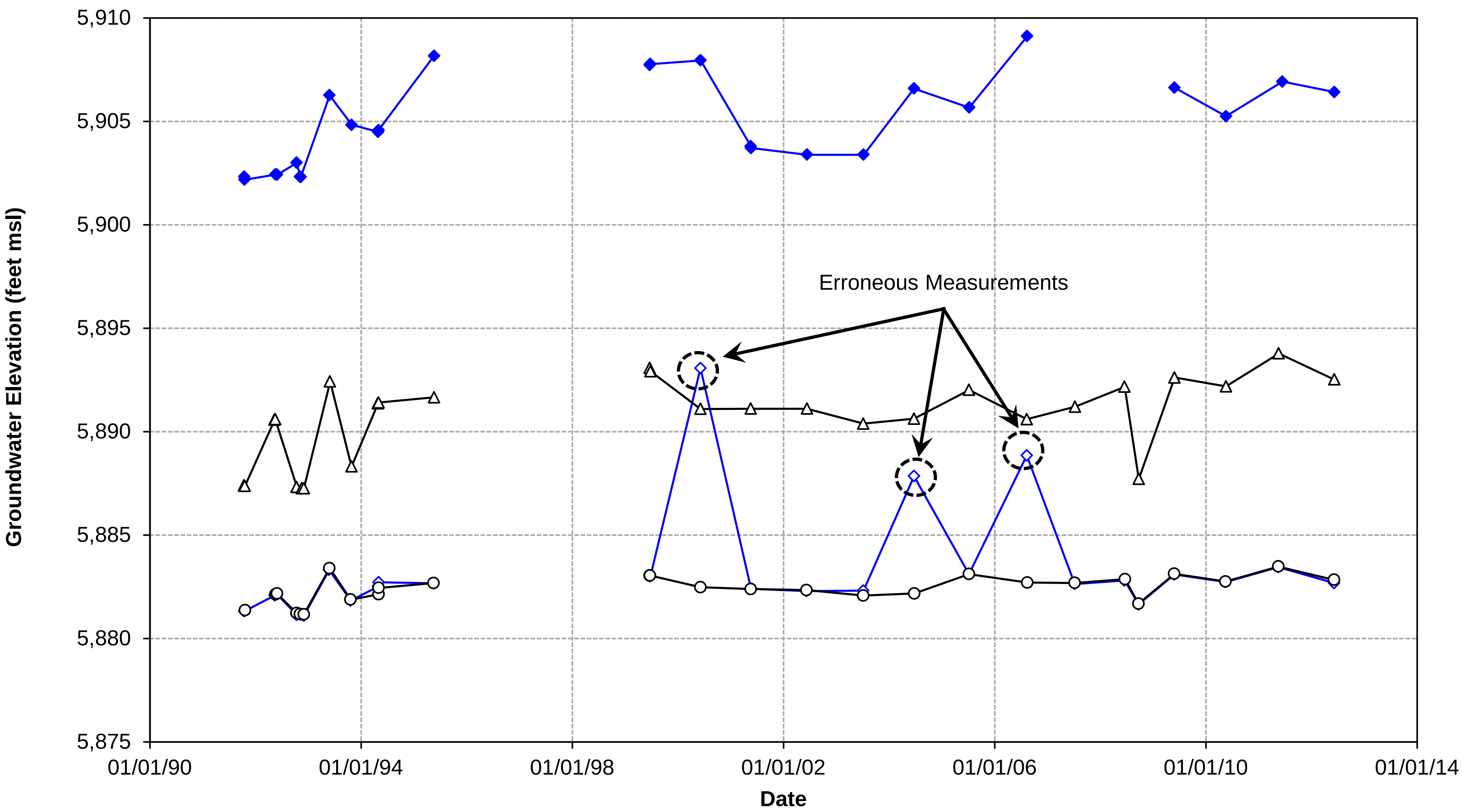
LEGEND

- TW-22
- TW-24
- Departure from Average Water Year Precipitation since 1990

FIGURE **5-4**

TW-22 and TW-24 Constituent Concentrations and Departure from Average Water Year Precipitation

Monsanto/Source Area Charactrization/ID



LEGEND

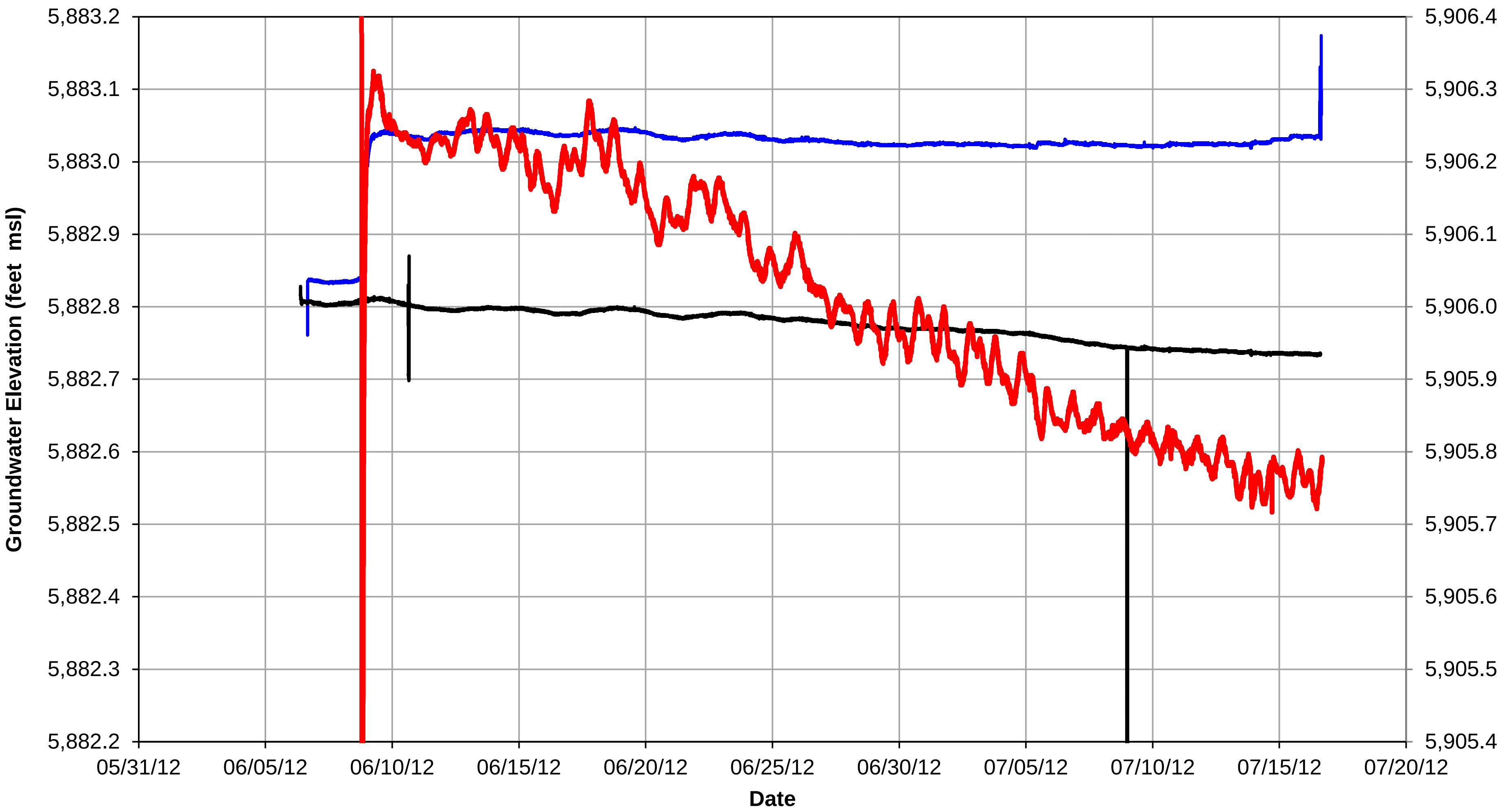
TW-22 (UBZ-2) TW-24 (UBZ-2)

TW-37 (UBZ-2) TW-26 (UBZ-4)

FIGURE **5-5**

GROUNDWATER ELEVATIONS IN UBZ-2 SOURCE AREA WELLS AND TW-26

Monsanto/UBZ-2 Source Area Char./ID



LEGEND

TW-22 (UBZ-2)

TW-24 (UBZ-2)

TW-26 (UBZ-4)

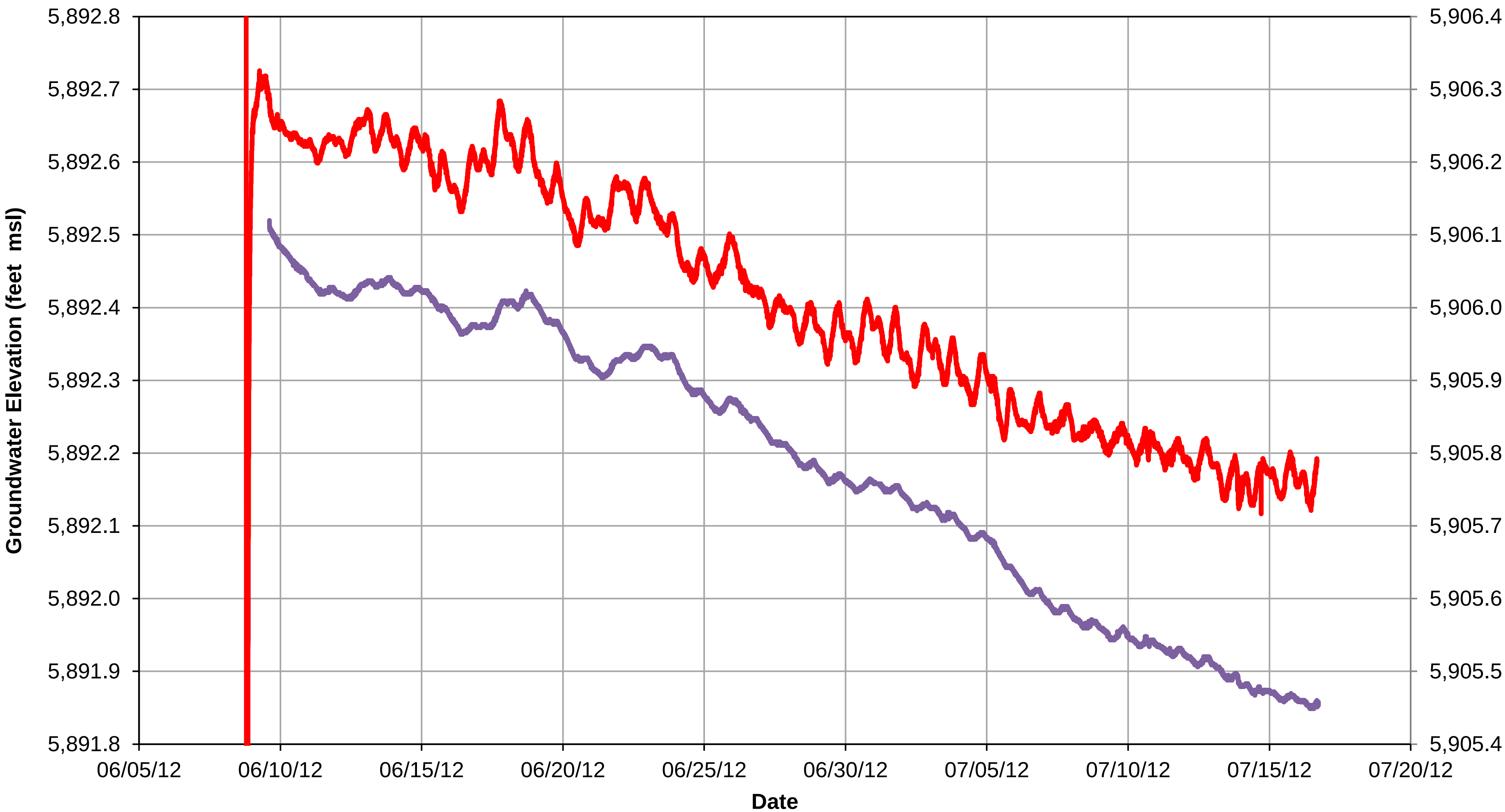
FIGURE **5-6a**

GROUNDWATER ELEVATION RESPONSE TO PLANT WELL PUMPING (TW-26, TW-22, AND TW-24)

Monsanto/UBZ-2 Source Area Char./ID

Figures 5-5 and 5-6a-b.xlsx

Golder Associates



LEGEND

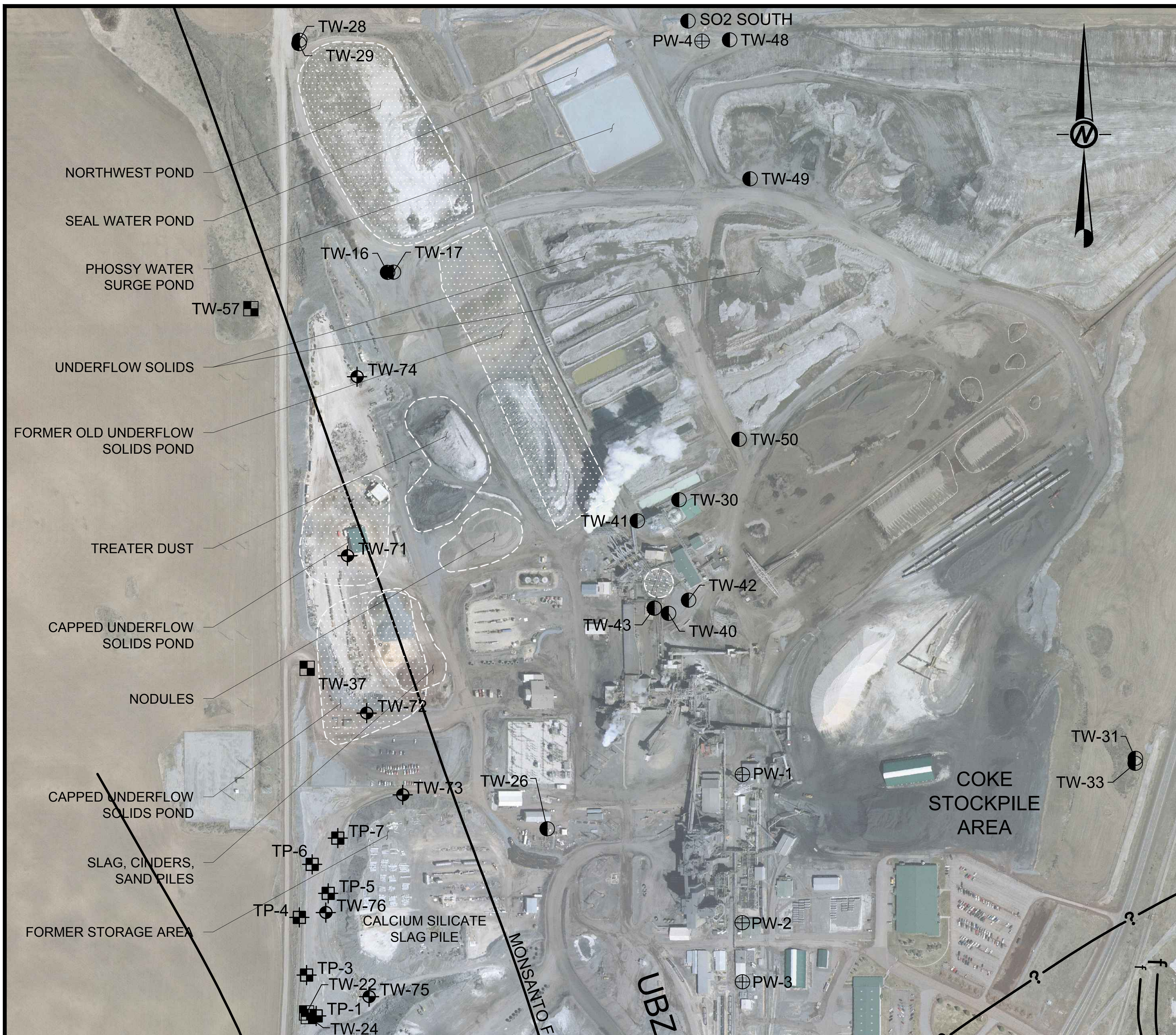
TW-37 (UBZ-2)

TW-26 (UBZ-4)

FIGURE **5-6b**

GROUNDWATER ELEVATION RESPONSE TO PLANT WELL PUMPING (TW-26 AND TW-37)

Monsanto/UBZ-2 Source Area Char./ID



LEGEND:

f —U/D— f FAULT	TW-60 MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-1	TW-71 PROPOSED BOREHOLE LOCATION WITH DESIGNATION	
f —U ? D— f FAULT (INFERRED)	LEWIS MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-2	TP-1 PROPOSED TEST PIT LOCATION WITH DESIGNATION	
f ········ f FISSURE	TW-33 MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4		
UBZ-1 GROUNDWATER ZONE			

0 500 1000

SCALE IN FEET

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/18/2011).

FIGURE **7-1**

2011

PROPOSED BOREHOLE AND TEST PIT LOCATIONS

Monsanto/Soda Springs 5 yr Review - Annual GW+SW Sampling/UBZ-2 Invest.

K:\CAD\Projects\1991\9131101\x002\002\2G\913-1101_002_002_2G_F7-1.dwg | F7-1 | Mod: 10/10/2012, 11:02 | Plotted: 10/10/2012, 11:04 | JAsprinio

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APPENDIX A
CHEMICAL HYDROGRAPHS

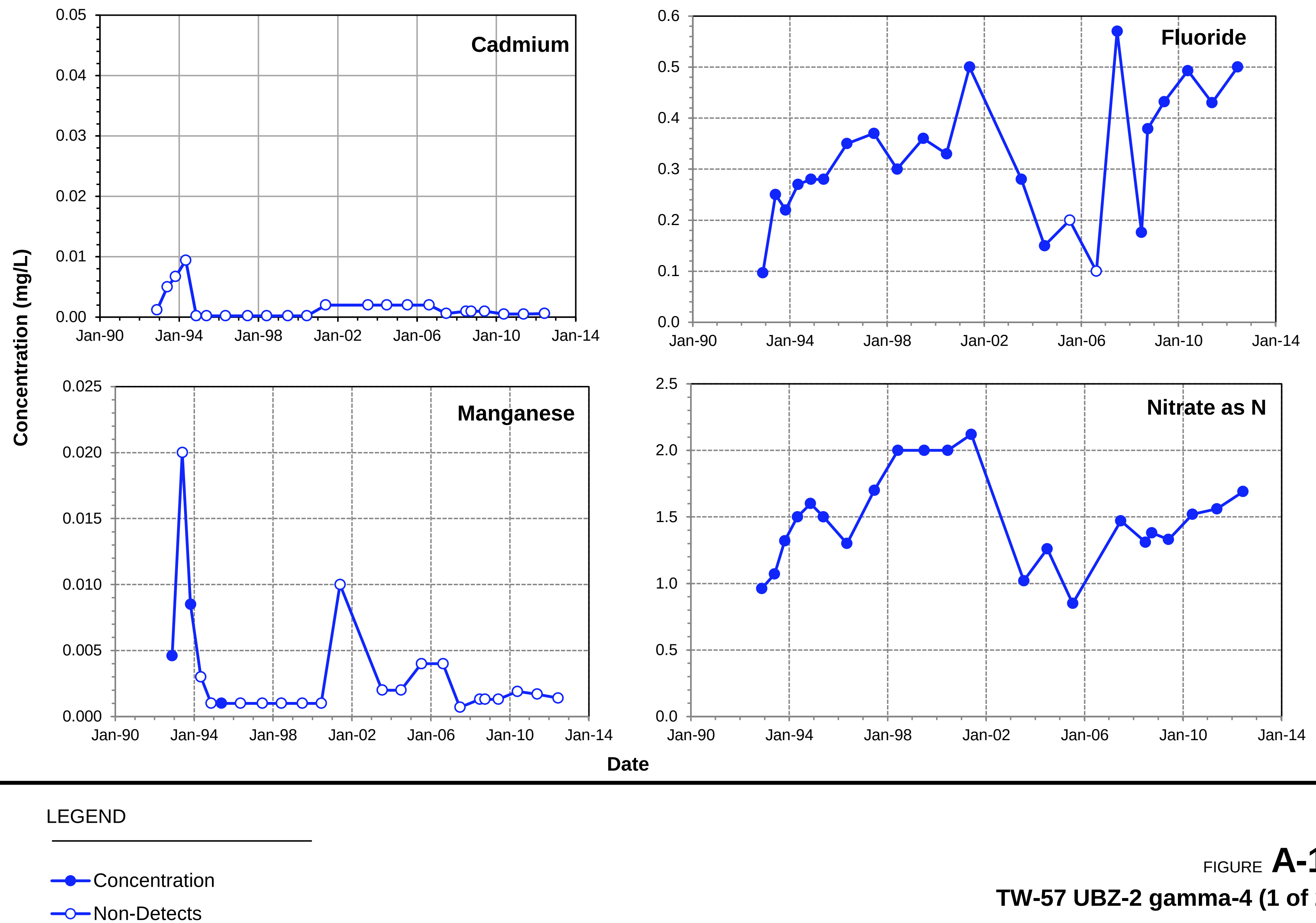


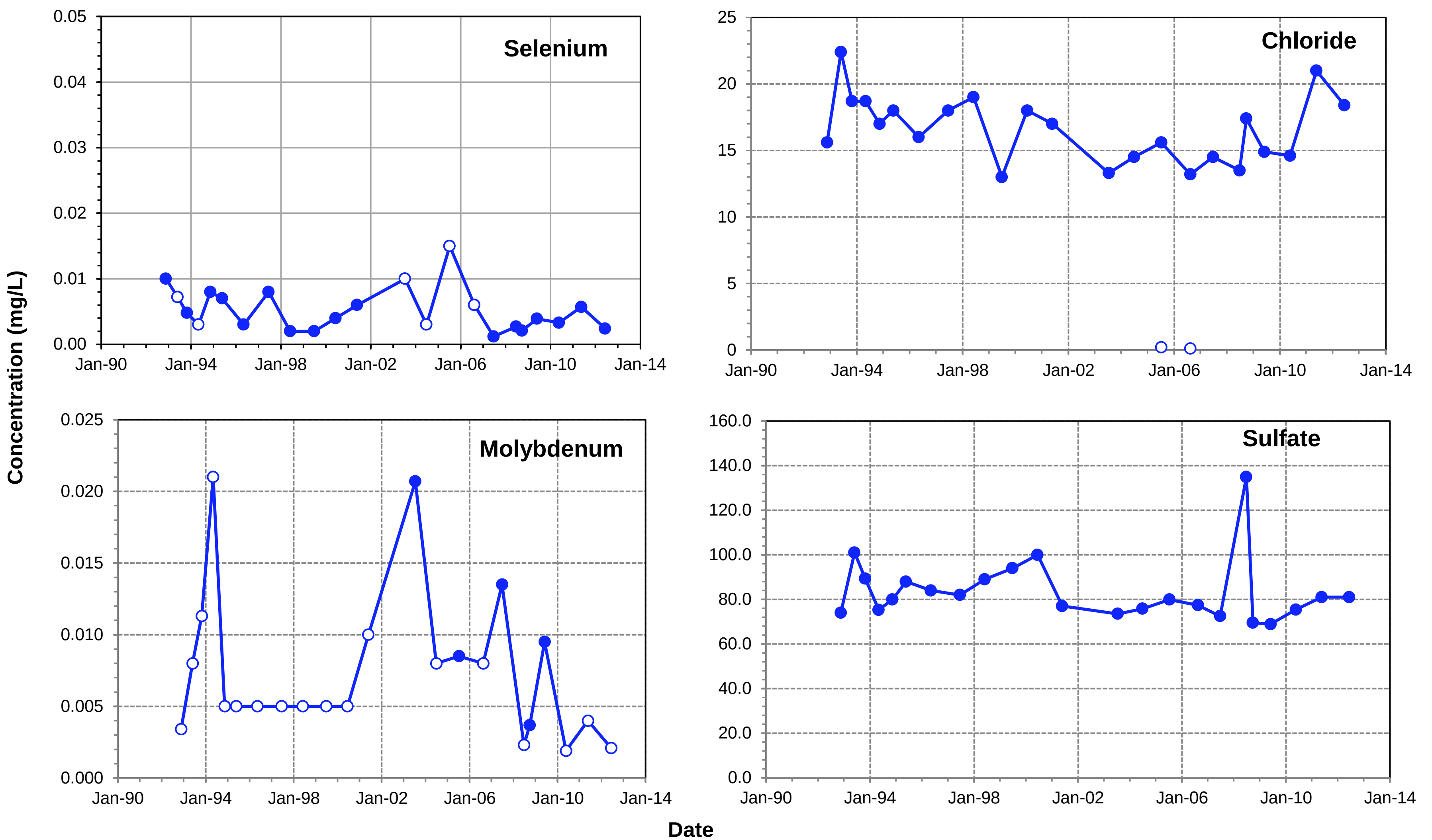
FIGURE **A-1**

TW-57 UBZ-2 gamma-4 (1 of 2)

Monsanto/Source Area Charactrization/ID

Appendix A.xlsx

Golder Associates



LEGEND

Concentration

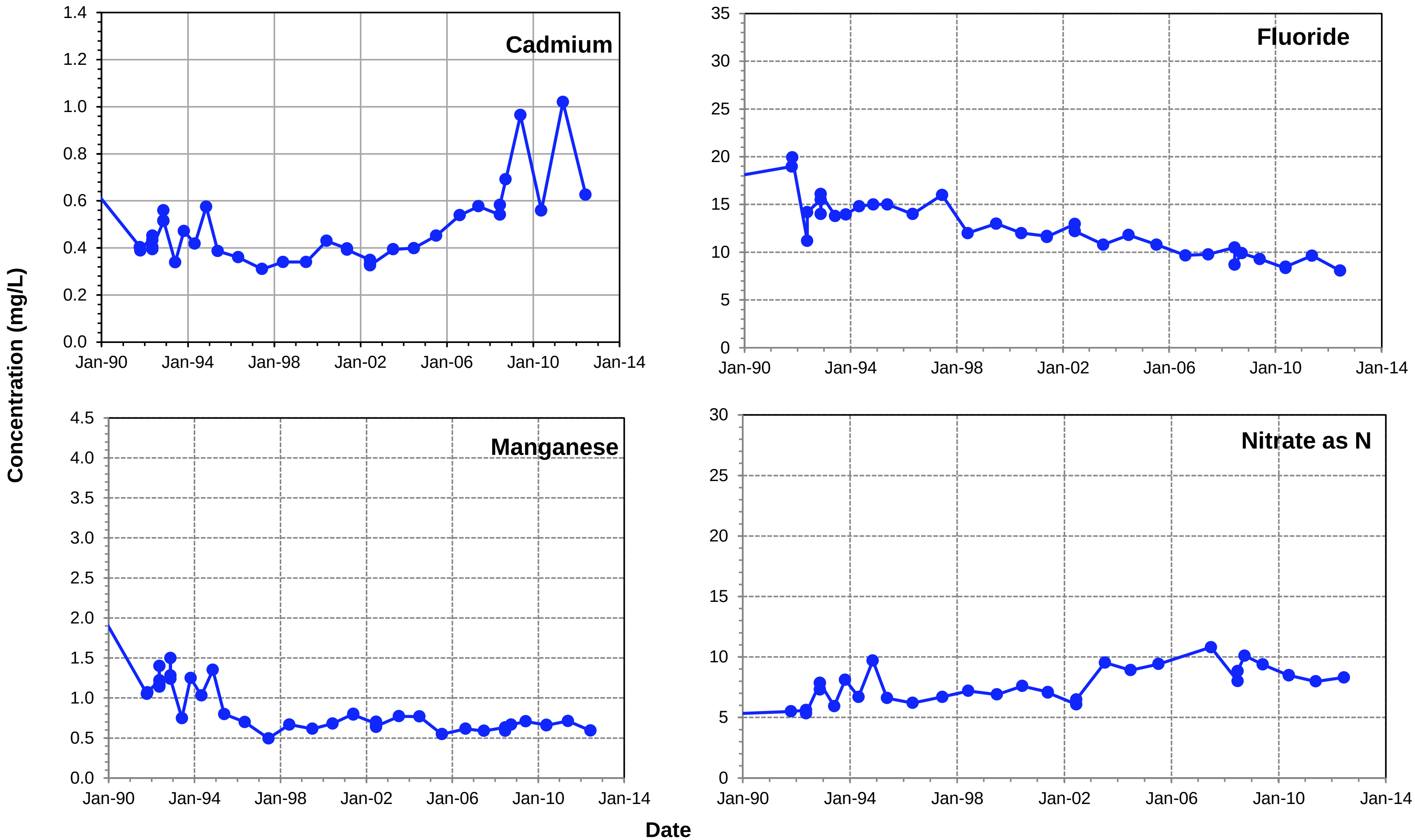
Non-Detects

FIGURE **A-2**

TW-57 UBZ-2 gamma-4 (2 of 2)

Monsanto/Source Area Charactrization/ID

Golder Associates



LEGEND

Concentration
Non-Detects

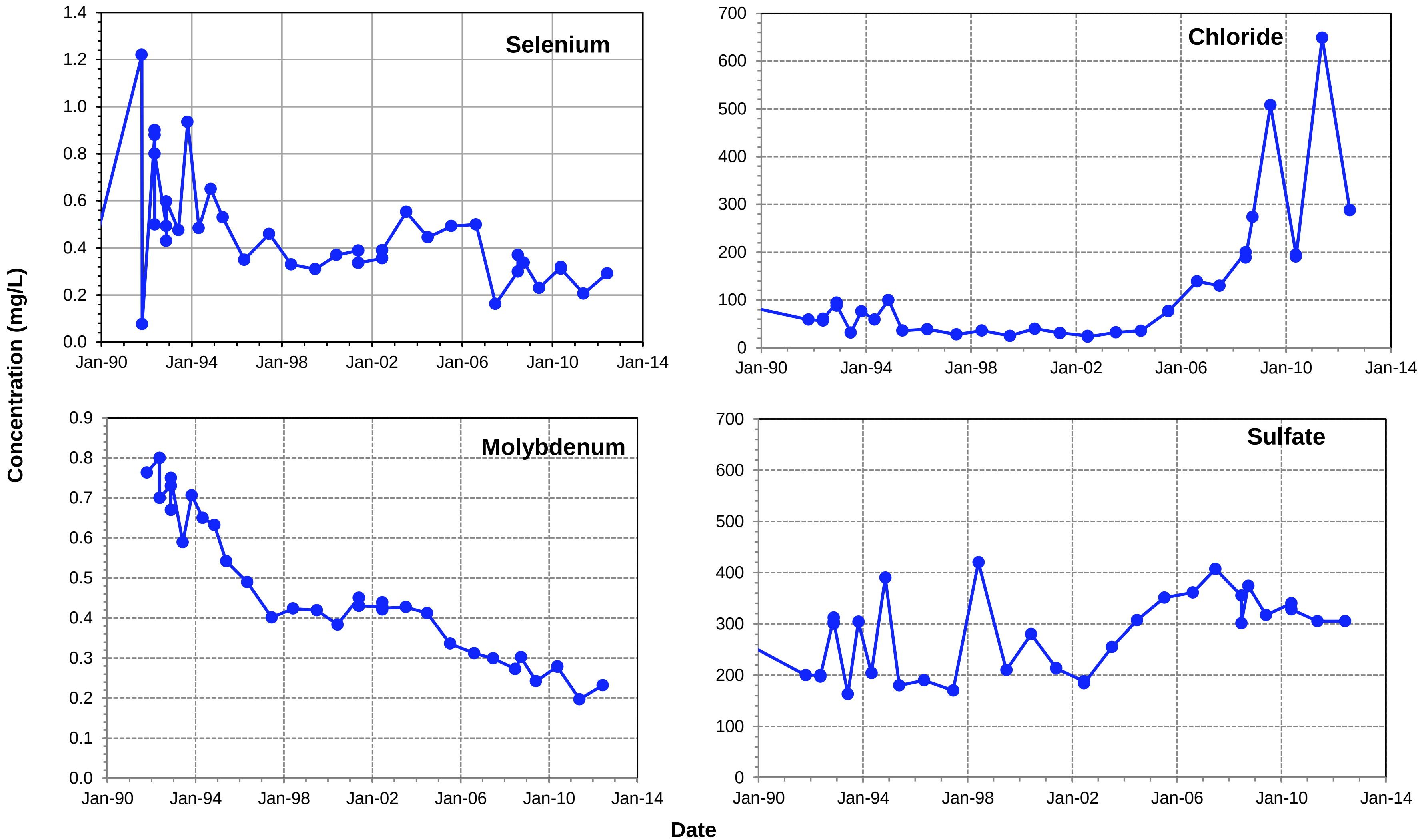
FIGURE **A-3**

TW-37 UBZ-2 gamma-3 (1 of 2)

Monsanto/Source Area Charactrization/ID

Appendix A.xlsx

Golder Associates



LEGEND

Concentration

Non-Detects

FIGURE **A-4**

TW-37 UBZ-2 gamma-3 (2 of 2)

Monsanto/Source Area Charactrization/ID

Golder Associates

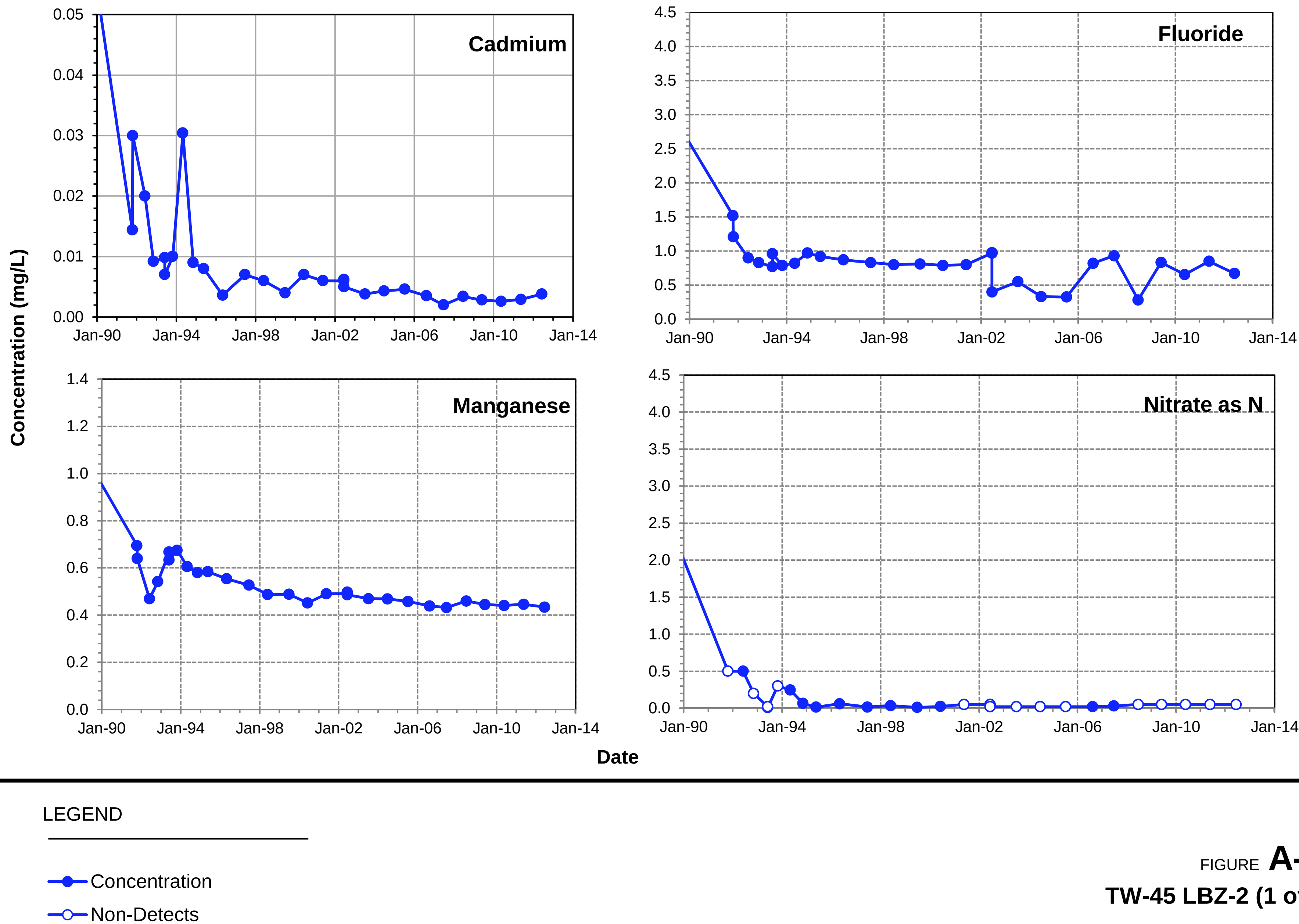
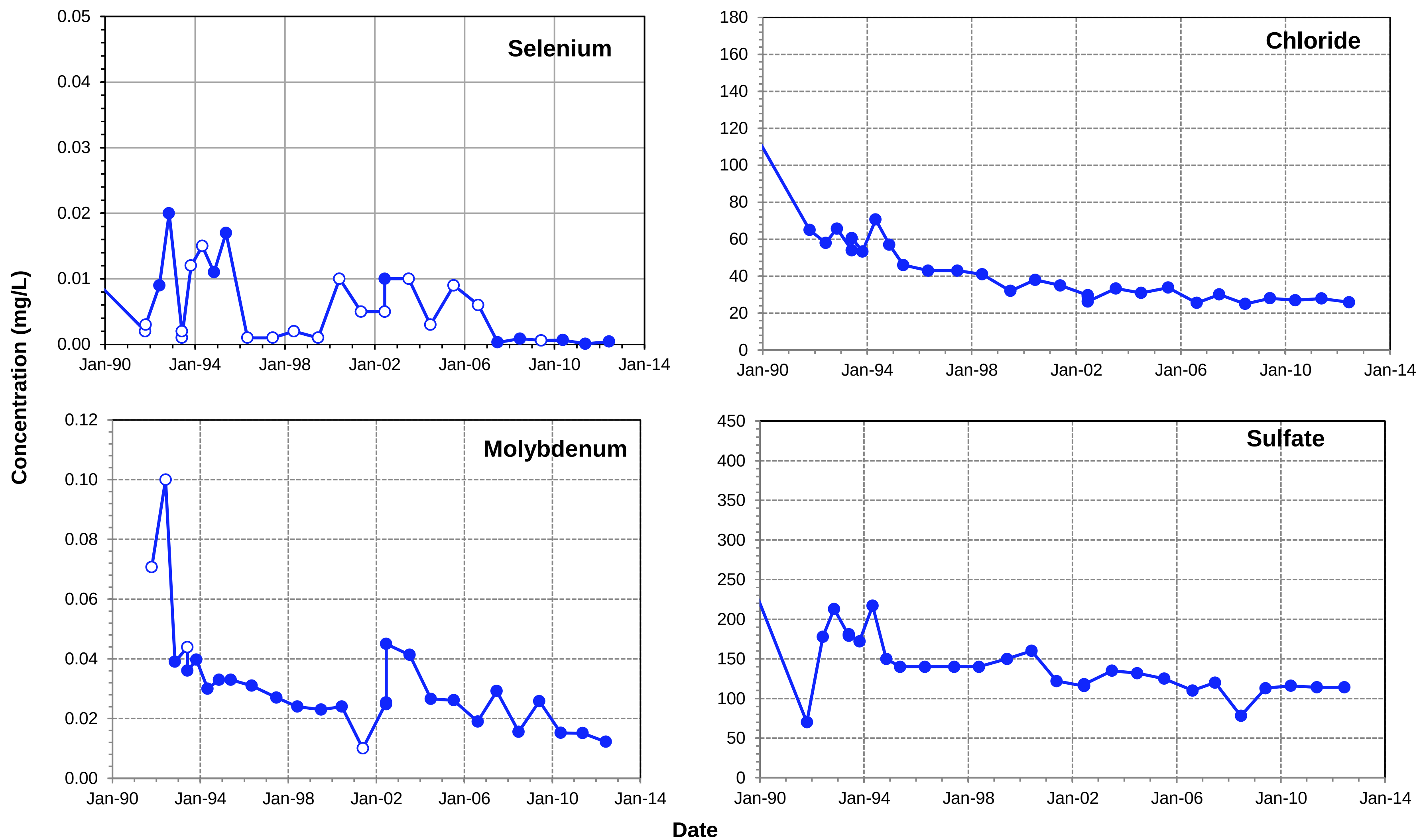


FIGURE **A-5**

TW-45 LBZ-2 (1 of 2)

Monsanto/Source Area Charactrization/ID



LEGEND

Concentration

Non-Detects

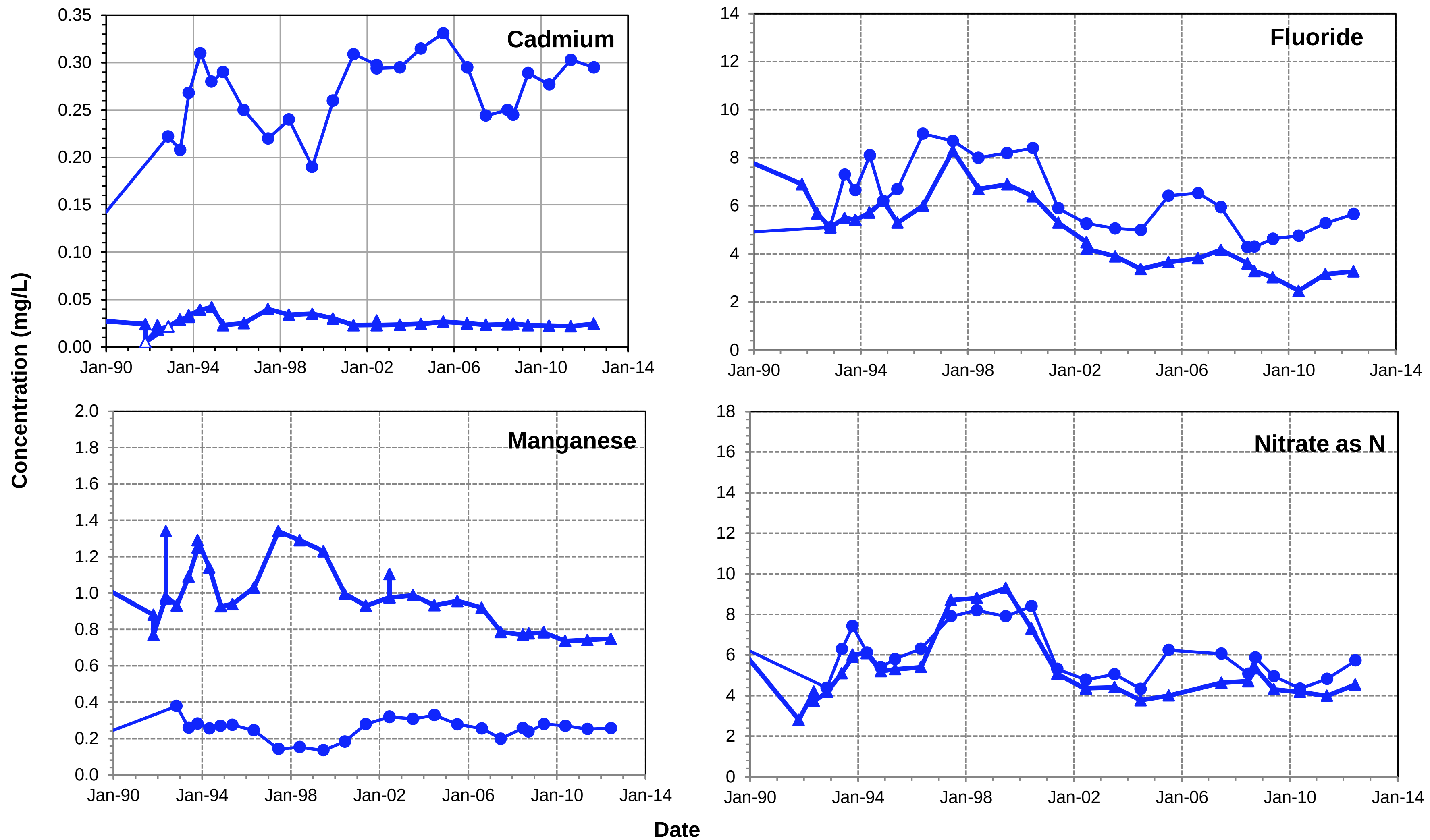
FIGURE **A-6**

TW-45 LBZ-2 (2 of 2)

Monsanto/Source Area Charactrization/ID

Appendix A.xlsx

Golder Associates



LEGEND

TW-24 Concentration

TW-24 Non-Detects

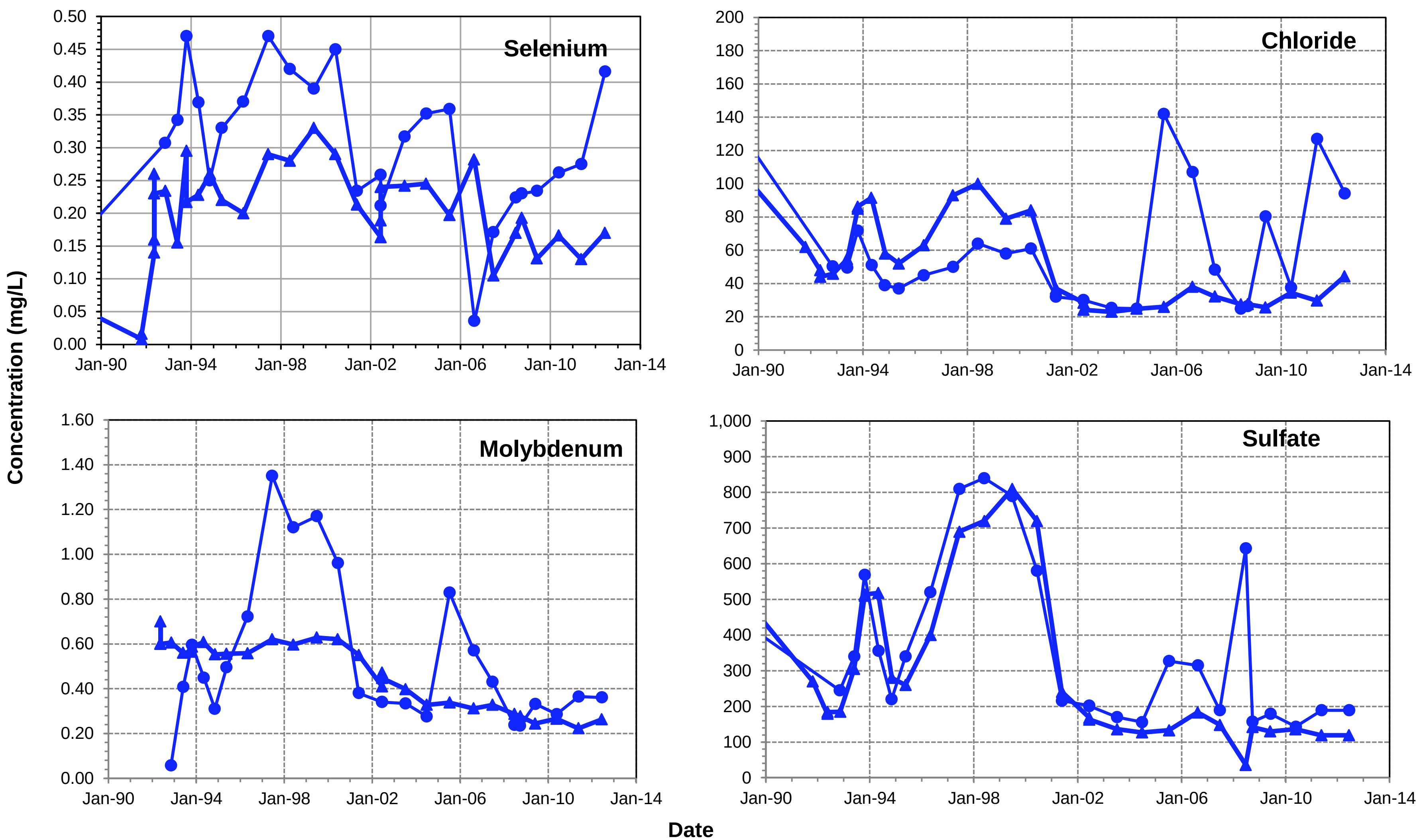
TW-22 Concentration

TW-22 Non-Detects

FIGURE **A-7**

TW-22 and TW-24 UBZ-2 gamma 4 (1 of 2)

Monsanto/Source Area Charactrization/ID



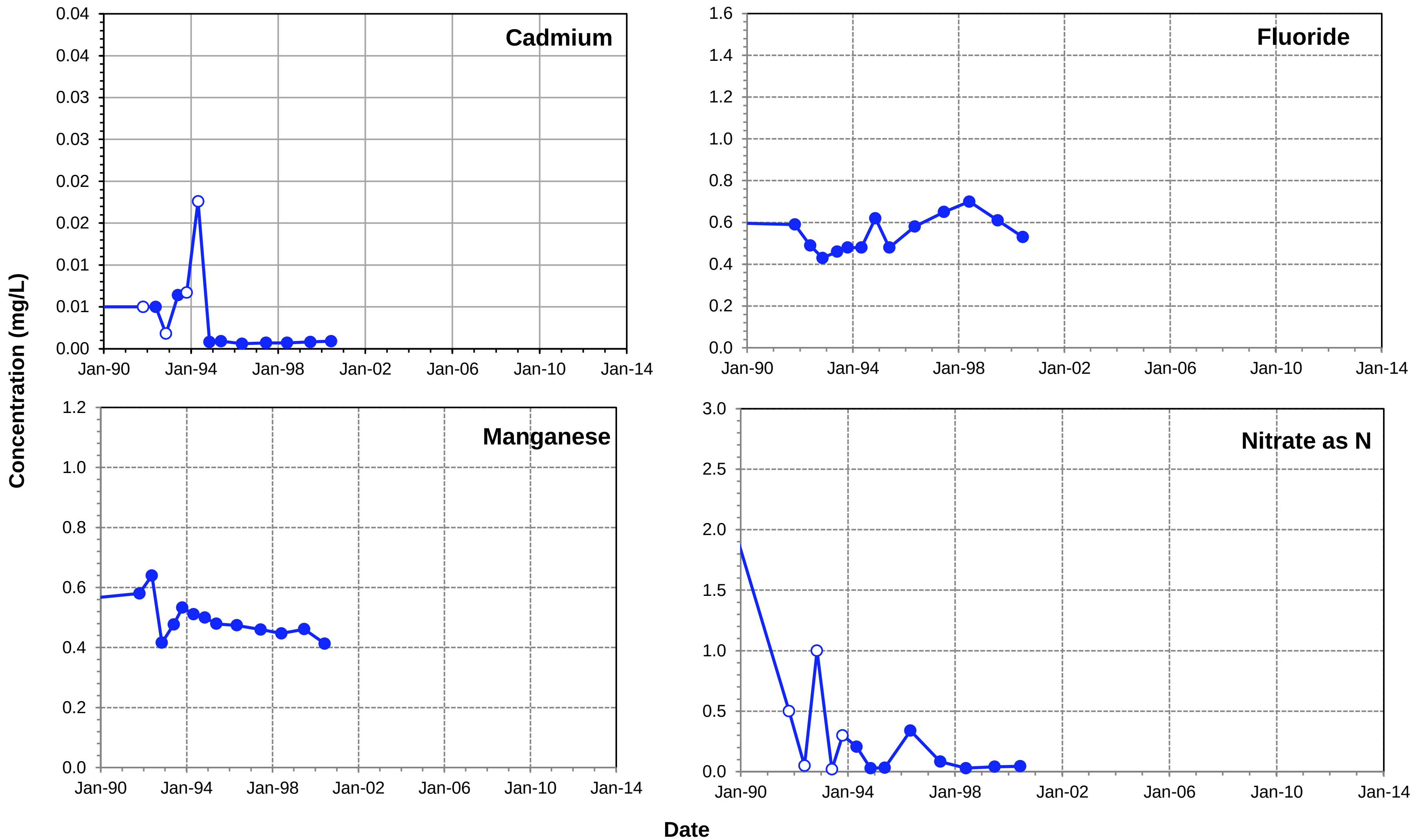
LEGEND

TW-24 Concentration
TW-24 Non-Detects
TW-22 Concentrations
TW-22 Non-Detects

FIGURE **A-8**

TW-22 and TW-24 UBZ-2 gamma 4 (2 of 2)

Monsanto/Source Area Charactrization/ID



LEGEND

Concentration

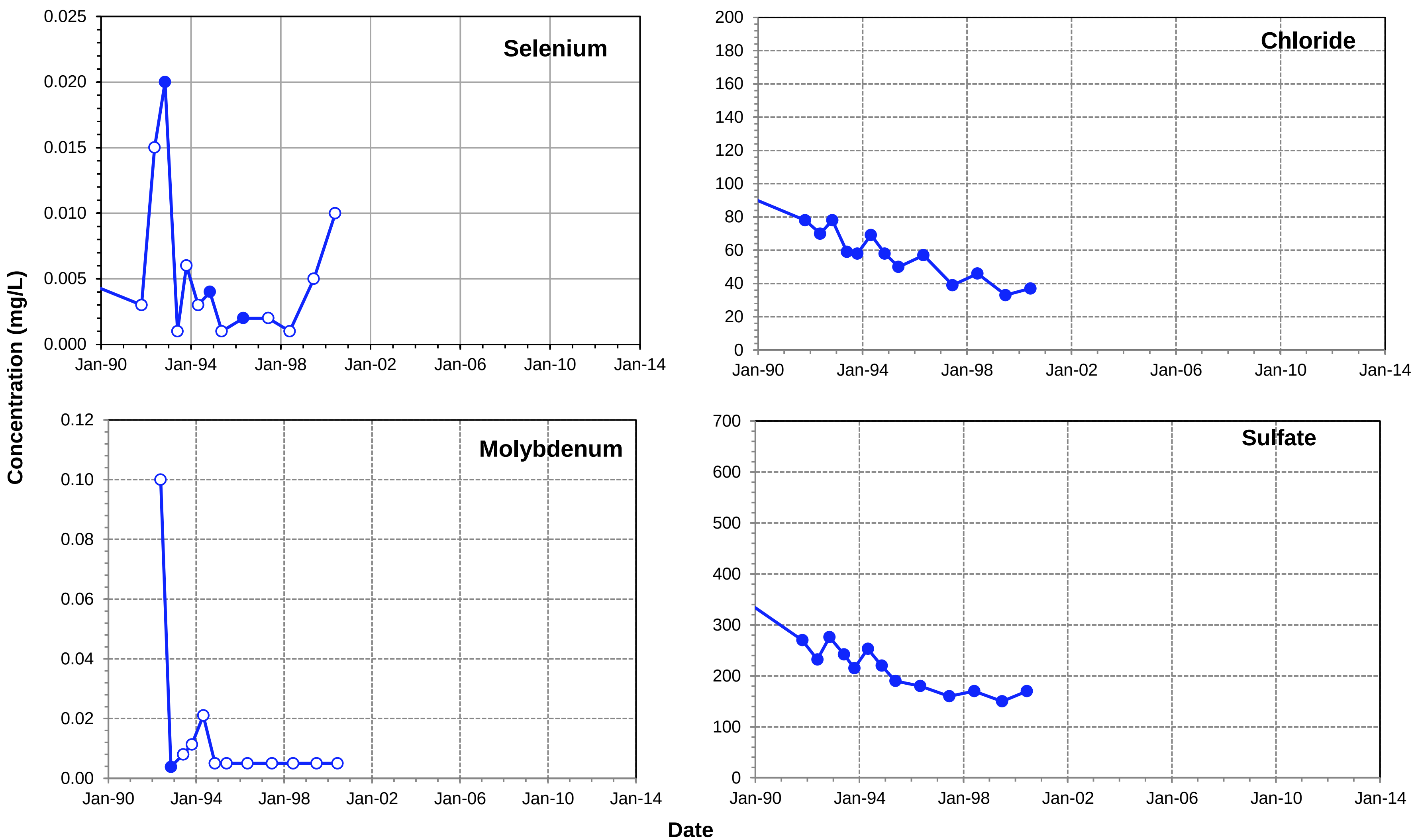
Non-Detects

Note:
No samples collected after June 2000

FIGURE **A-9**

TW-23 LBZ-2 (1 of 2)

Monsanto/Source Area Charactrization/ID



LEGEND

Concentration

Non-Detects

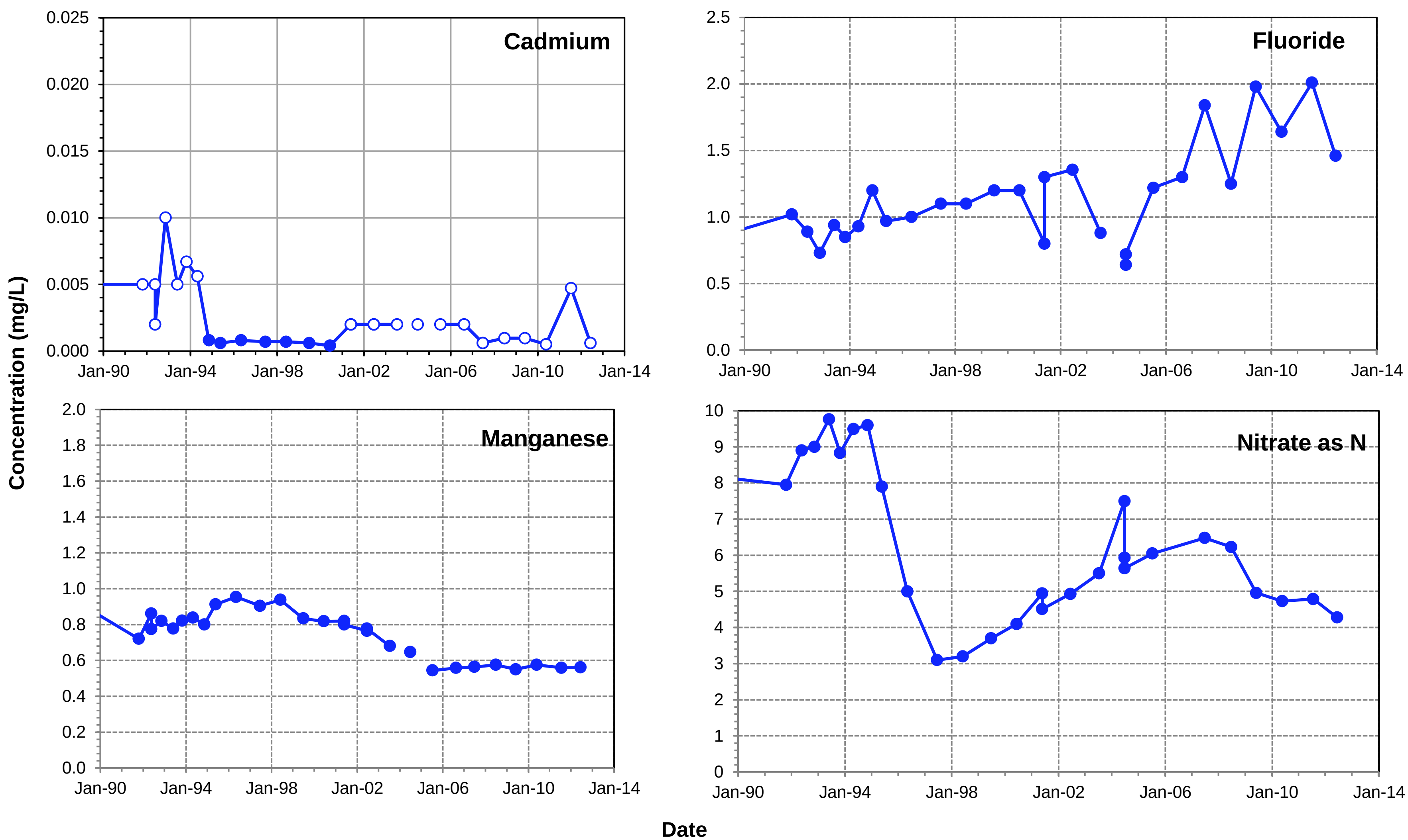
Note:
No samples collected after June 2000

FIGURE **A-10**

TW-23 LBZ-2 (2 of 2)

Monsanto/Source Area Charactrization/ID

Golder Associates



LEGEND

Concentration

Non-Detects

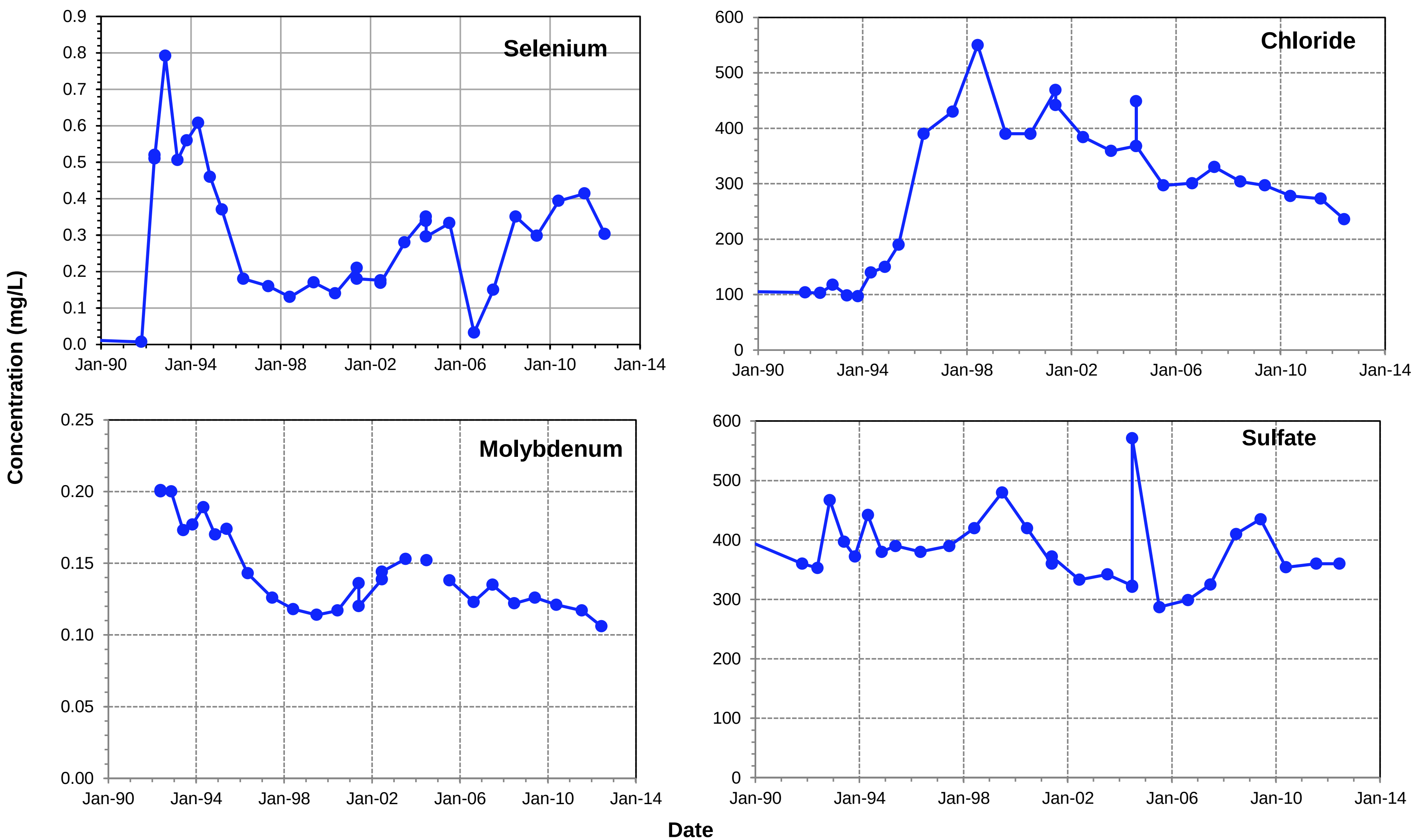
FIGURE **A-11**

TW-26 UBZ-4 gamma 2 (1 of 2)

Monsanto/Source Area Charactrization/ID

Appendix A.xlsx

Golder Associates



LEGEND

Concentration

Non-Detects

Note:
No samples collected after June 2000

FIGURE **A-12**

TW-26 UBZ-4 gamma 2 (2 of 2)

Monsanto/Source Area Charactrization/ID

Appendix A.xlsx

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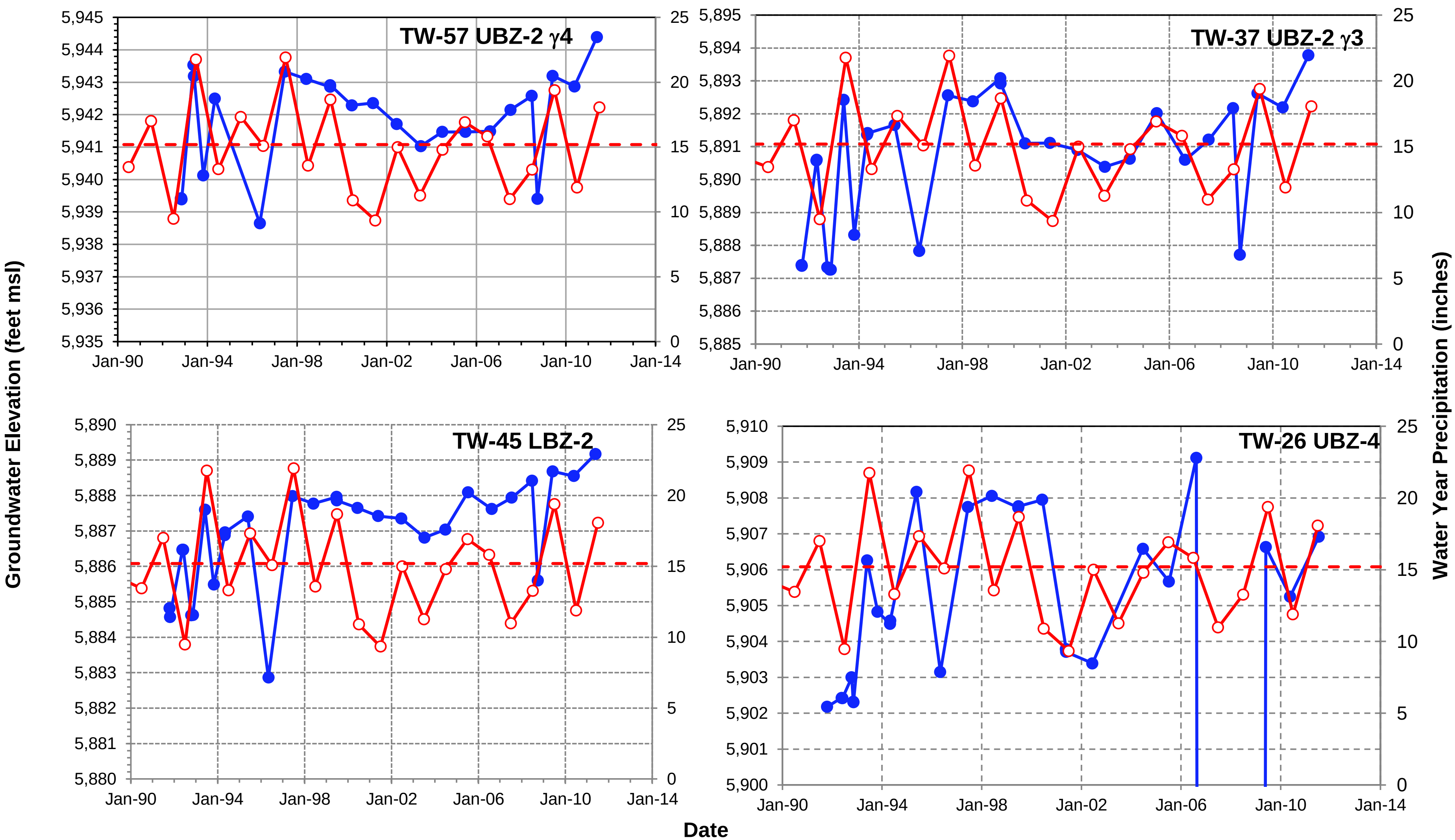
APPENDIX B
GROUNDWATER ELEVATIONS, PRECIPITATION AND CONSTITUENT CONCENTRATIONS



LEGEND

Groundwater Elevation

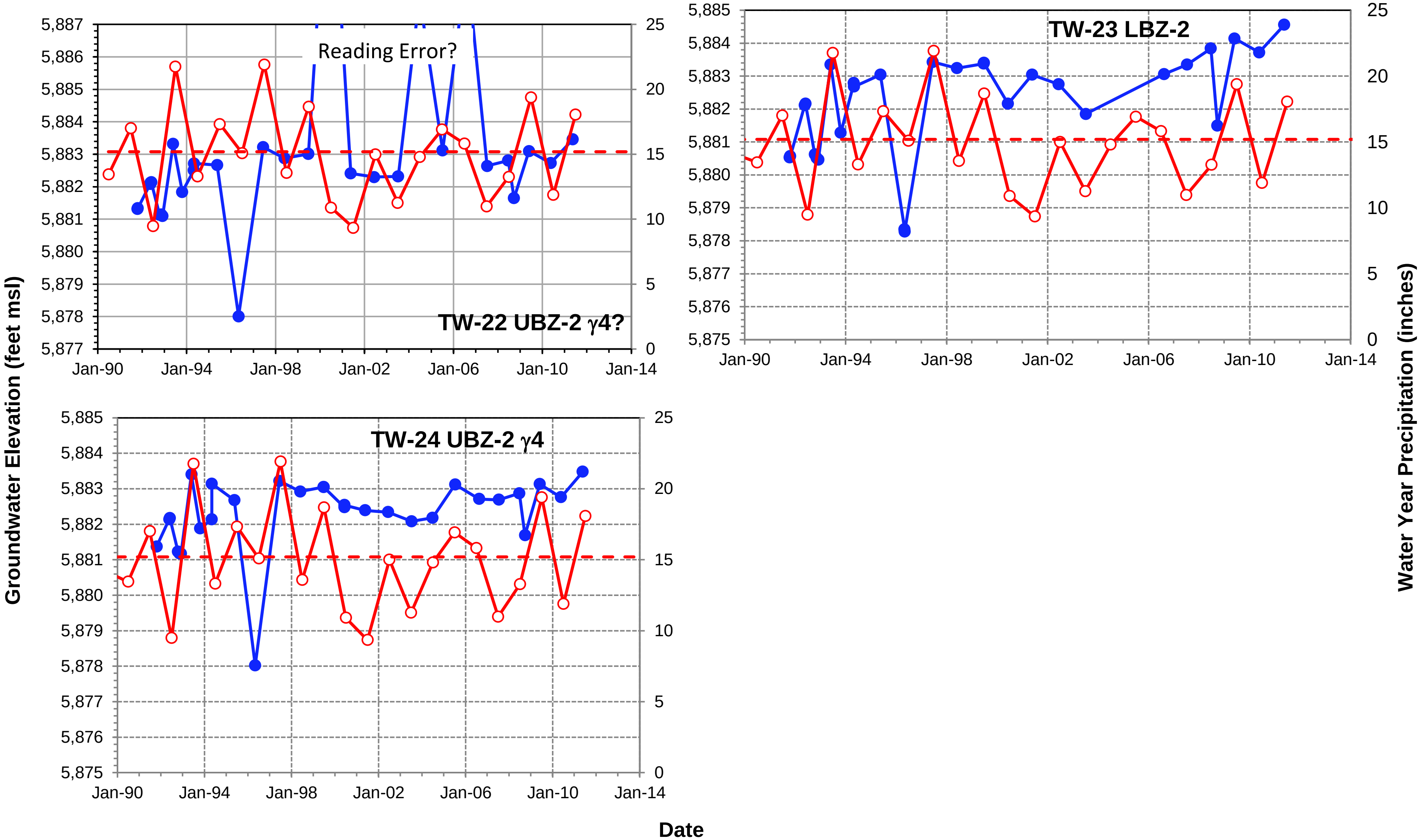
Precipitation

Average WY Precipitation

FIGURE **B-1**

GROUNDWATER ELEVATIONS AND PRECIPITATION

Monsanto/Source Area Charactrization/ID



LEGEND

Groundwater Elevation

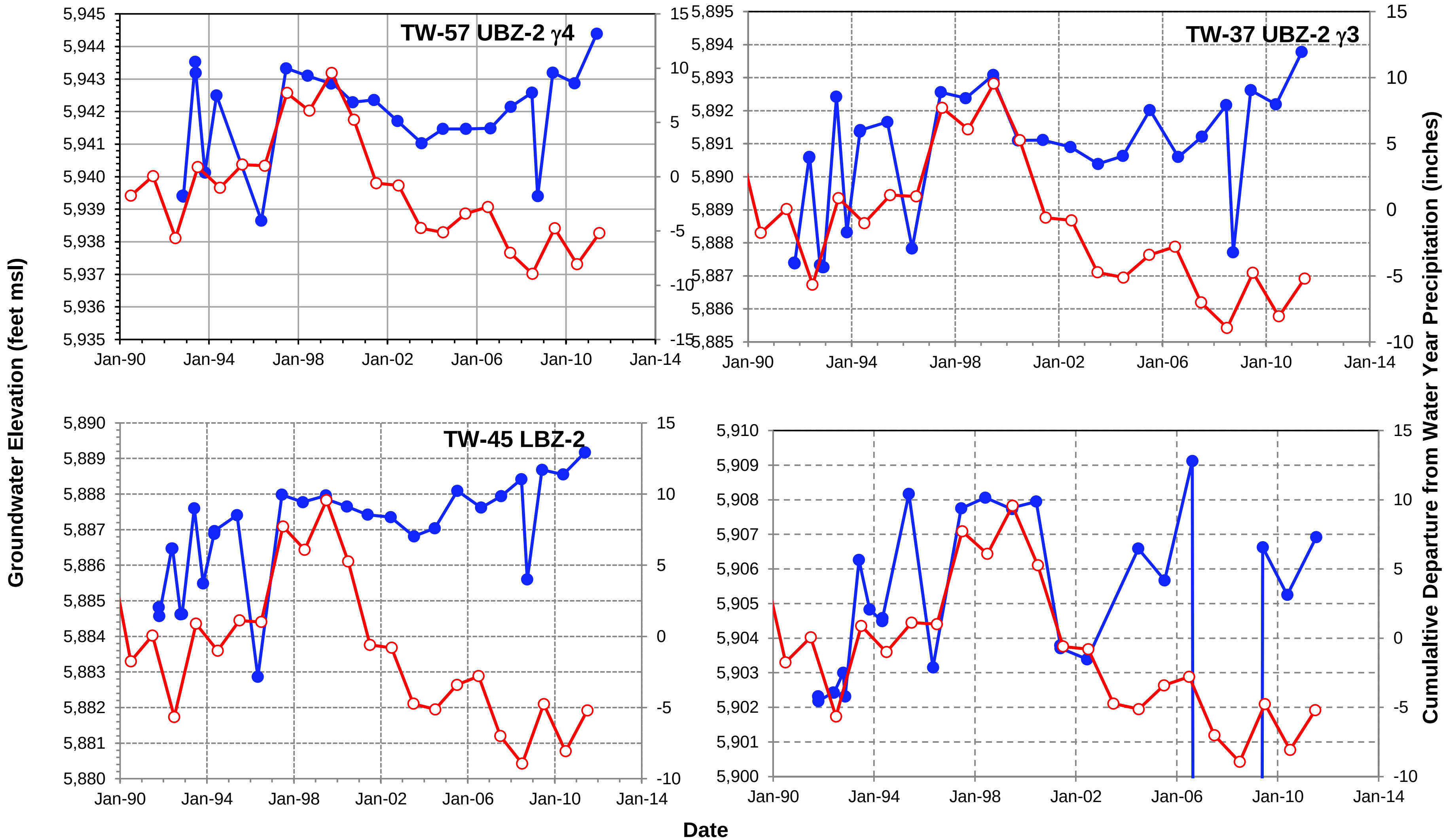
Precipitation

Average WY Precipitation

FIGURE **B-2**

GROUNDWATER ELEVATIONS AND PRECIPITATION

Monsanto/Source Area Charactrization/ID



LEGEND

Groundwater Elevation

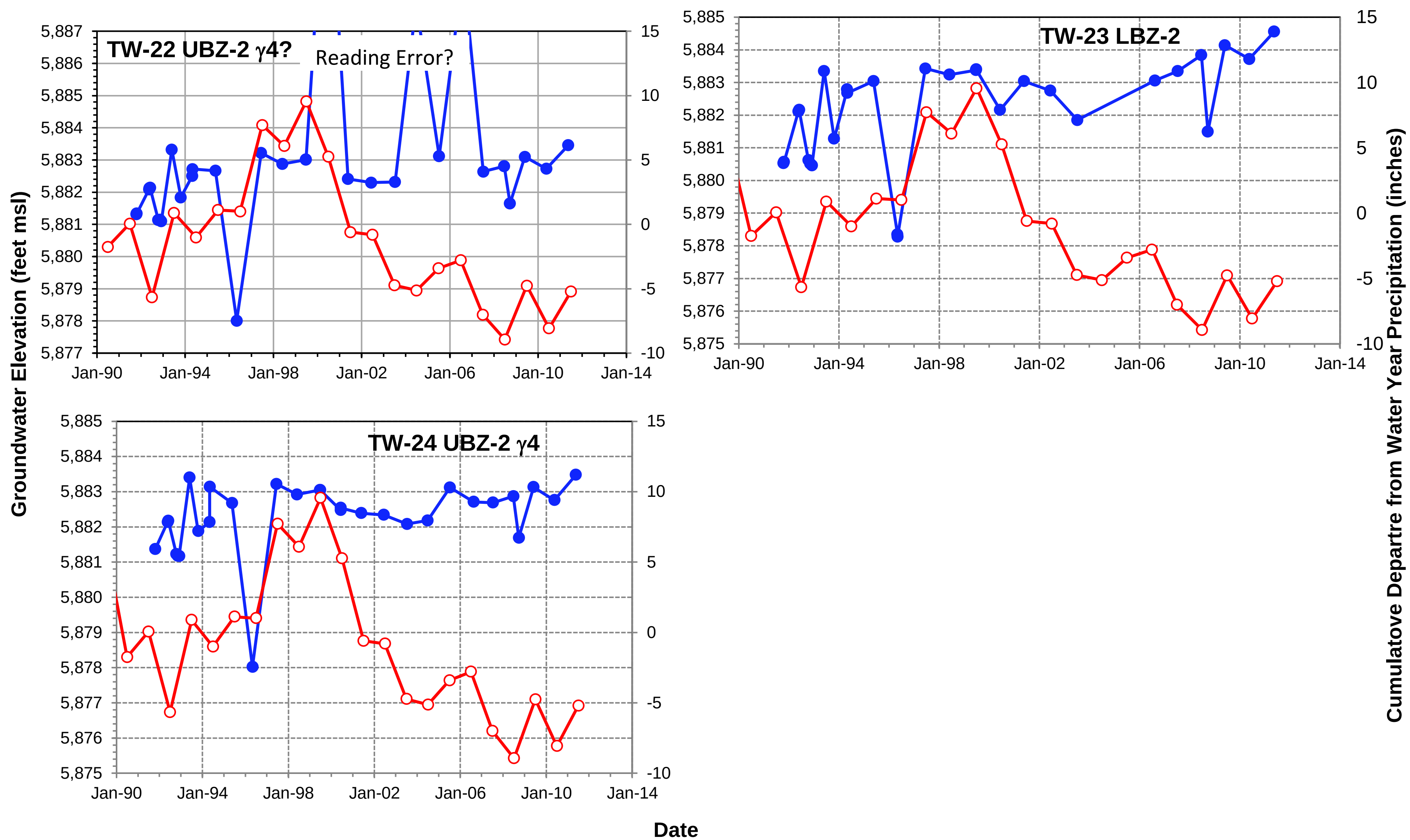
Departure from Average Water Year Precipitation since 1990

FIGURE **B-3**

GROUNDWATER ELEVATIONS AND DEPARTURE FROM AVERAGE WATER YEAR PRECIPITATION

Monsanto/Source Area Charactrization/ID

Golder Associates



LEGEND

- Groundwater Elevation
- Departure from Average Water Year Precipitation since 1990

FIGURE **B-4**

GROUNDWATER ELEVATIONS AND DEPARTURE FROM AVERAGE WATER YEAR PRECIPITATION

Monsanto/Source Area Charactrization/ID

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Inc.
18300 NE Union Hill Road, Suite 200
Redmond, WA 98052 USA
Tel: (425) 883-0777
Fax: (425) 882-5498